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UTILIZATION, DIFFUSION,
AND SUBSTITUTION OF
HIGH-TECHNOLOGY PROCEDURES

Final Report

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1.0 INTRODUCTION

1.1 Statement of the Problem

The rapid growth in Medicare Part B expenditures has been particularly noticeable in certain types of physician procedures. For example, Mitchell et al. (1989) found that while Part B physician spending per beneficiary increased 29.5 percent from 1983 to 1986, spending increased at even higher rates for surgery (35 percent), radiology (36 percent), and specialized diagnostic tests, like ECGs, (67 percent). Together, these three types of service accounted for two-thirds of the spending growth over this time period.

Surgery alone accounted for 41 percent of the increase. Surgical procedures which were increasing at higher than average rates during the 1983-1986 study period included lens (cataract) procedures, colonoscopy, coronary artery bypass graft surgery, cardiac catheterization, upper GI endoscopy, and knee replacement. All of these procedures are examples of relatively new medical technologies.

The purpose of this research project is to analyze the growth in utilization rates and the patterns of diffusion for three groups of high-technology physician services: one of each group representing a very recent innovation, and other relatively more established. Specific research questions include the following:

- To what extent is the increase in high-technology services a result of technology diffusion to new areas, rather than a result of increased utilization within the same limited geographic areas?
- To what extent does the increase in high-technology services represent an increase in the number of individual beneficiaries using the service, rather than an increase in the number of services per individual user?
- As technologies diffuse, how much variability is observed in utilization rates (and by implication, in access to such technology) of Medicare beneficiaries? Does the black-white utilization "gap" in cardiac procedures noted by other researchers narrow over time?

- During initial stages of the diffusion of a particular technology, both high and low utilization rates are observed over a range of geographic areas. As the diffusion process nears completion, do utilization rates converge, or do geographic areas with initially high utilization rates (areas with earlier diffusion) continue to demonstrate higher-than-average use?
- In many instances, advancements in medical technology have resulted in the development of a newer technology that parallels a somewhat older technology, with similar indications and benefits, and similarly high costs. One example of such pairs of overlapping technologies is percutaneous transluminal coronary angioplasty (PTCA) and coronary artery bypass graft (CABG) surgery. As the newer technology diffuses, to what extent does it replace or substitute for the older technology? To what extent is it used in addition to the older technology in the same patient?

Such questions are of great importance to Medicare decision-makers, since the answers will clearly influence efforts to encourage or discourage rates of diffusion and increases in utilization of new, high-cost physician services.

1.2 Technologies Selected for Analysis

The three groups of procedures selected for analysis in this project were:

- Magnetic resonance imaging (MRI) of the head versus computerized axial tomography (CT) of the head;
- Percutaneous transluminal coronary angioplasty (PTCA) versus coronary artery bypass graft (CABG) surgery;
- Extracorporeal shock wave lithotripsy (ESWL) versus open and endoscopic surgical techniques for eliminating stones from the kidney and upper urinary tract.

At least one of the procedures in each group meets the following criteria:

- The procedure involves relatively high Part B physician reimbursement per unit of service under Medicare;
- The procedure has undergone a disproportionately rapid increase in utilization;
- Because of either high initial equipment costs or prolonged physician training requirements (or both), diffusion of the procedure occurs over a sufficiently long period of time (several years) to be observable through Medicare Part B claims.

In addition, each group of procedures is an example of competing technologies which might be expected to substitute for one another in many circumstances, but which may actually be

used conjunctively. The technologies as a group involve several physician specialties including radiology, cardiology, cardiothoracic surgery, and urology.

1.2.1 Issues Relevant to CABG and PTCA Treatment of Coronary Artery Disease

Coronary artery bypass graft (CABG) surgery was developed twenty years ago to treat patients with severe coronary artery disease. By 1987, more than 230,000 such procedures were performed in nonfederal hospitals in the U.S. (Killip, 1988). The procedure involves replacement of partially or totally obstructed segments of coronary arteries with segments of veins or arteries harvested from elsewhere in the patient's body. The procedure has been used to reduce the risk of myocardial infarction and death in patients with high-risk lesions, and to improve symptoms and quality of life in patients whose symptoms are not easily managed by medications alone. Although short-term improvements in mortality and quality of life have been documented, the grafts may also become occluded over time, and the advantage of bypass surgery over medical therapy eventually declines.

Percutaneous transluminal coronary angioplasty (PTCA) has been available since 1977. It has been used as a substitute both for CABG surgery and for medical management of anginal symptoms. The procedure involves advancing a balloon-tipped catheter to the point of obstruction within a coronary artery, and then inflating the balloon to dilate the obstructed artery. Since its introduction, use of PTCA has increased in patients with more extensive coronary disease, with more advanced age, and with other medical risk factors (Detre et al., 1988). Despite more aggressive use of the technique, initial success in dilating obstructions and the rate of complications have both improved. However, the frequency of recurrence of obstruction within dilated arteries has remained at 25 to 35 percent of patients (McBride et al., 1988).

Given the frequent recurrence of obstruction after either procedure (CABG or PTCA) and the consequent decrease in therapeutic advantage, questions have been raised regarding the appropriate timing of these procedures within the course of a patient's disease process. Earlier surgical intervention may prevent deterioration of cardiac function or death in

some patients, but many patients will also need to have repeated surgical procedures because of recurrent obstructions. While obstructions occurring after PTCA are often easily treated by repeated PTCA, re-obstructions occurring after CABG are more risky: mortality for a second CABG procedure is 11.7 percent, or four times the mortality of the initial procedure (Killip, 1988). For this reason, many cardiologists prefer to use PTCA as an initial procedure in patients who require surgical intervention for coronary artery disease, and to reserve CABG procedures for patients with more severe or recurrent disease. The implication of these medical data is that many Medicare beneficiaries will undergo not one but several of these procedures for coronary artery disease, including both PTCA and CABG procedures. Thus, PTCA is an example of an expensive technology that may be used in addition to, rather than in place of, an older technology with similar indications, benefits, and costs.

Another health policy issue raised by PTCA is the concern over potential conflict of interest for physicians who both determine that the new procedure is necessary and then provide the service to the patient. For a patient being considered for CABG surgery, the typical scenario is that a cardiologist would make the diagnosis of severe or medically-unmanageable coronary artery disease, and would refer the patient to a cardiothoracic surgeon, who would perform the procedure. With PTCA, a single cardiologist may diagnose severe coronary artery disease, perform coronary angiography to determine that PTCA is necessary, perform the PTCA procedure itself, and evaluate the outcome and the appropriateness of the therapy. There is a potential conflict of interest in the self-referral of patients for an expensive procedure, and thus a potential for excessive and inappropriate utilization of the procedure.

1.2.2 Issues Relevant to CT and MRI Scanning

Computerized axial tomography became clinically available in 1973. Since it was the first radiologic technique to offer high-resolution cross-sectional images in multiple planes, it greatly improved the diagnostic capabilities of physicians for a number of medical conditions. Despite its high cost and despite attempts to control its diffusion through the

Determination of Need (DON) process, CT scanning over the next decade became a standard imaging technique for both inpatient and ambulatory medical conditions. In 1980, magnetic nuclear resonance imaging (MRI) an imaging technique based on a different physical principle, but offering similar high-resolution cross-sectional multiple-plane imaging) became available to clinicians. Despite a number of clinical, economic, and technical obstacles (including unclear advantages over CT, much higher acquisition costs, a markedly different inpatient reimbursement environment, and uncertainty over outpatient reimbursement), MRI has also diffused quickly since its introduction (Hillman and Schwartz, 1985). However, uncertainty over the indications for and clinical advantages of MRI in place of CT leads many to suspect that MRI is frequently used in addition to, rather than as a substitute for, CT imaging.

Many of the forces that might have been expected to hinder the diffusion of MRI technology (such as its high cost, uncertainty over reimbursement, and DON requirements) have instead acted largely to shift the location of many new MRI units from hospitals (the traditional location of expensive medical technology) to free-standing centers, many owned by physician-investors. In 1984, 57 percent of MRI units were in non-hospital settings, with nearly one-half of these units owned by groups of physician investors (Hillman and Schwartz, 1985).

Increased non-hospital siting of, and physician investment in, MRI technology has several implications for utilization and reimbursement of these services under Medicare Part A. When MRI units are sited in hospitals, the technical component of MRI procedures for inpatients would be reimbursed under Part A. When MRI units are located in non-hospital settings, both the technical and professional (interpretation) components of MRI scanning would be reimbursed under Medicare Part B. Estimated 1988 Part B reimbursement for MRI interpretation alone (head scan) is $200, while reimbursement for the technical component of the same procedure is $550 (total reimbursement of $750 per procedure). Thus, the inclusion of the technical component under Part B means a significant increase in Part B expenditures per unit of service.

Increasing physician investment in non-hospital MRI units raises concerns regarding utilization as well as reimbursement. The physician-investors in these cases are typically clinicians who in the course of their practices need to refer patients for imaging procedures such as CT and MRI. Physician ownership of such units can create conflicts of interest which may result in inappropriate and excessive utilization of such expensive technology.

1.2.3 Issues Relevant to Extracorporeal Shock Wave Lithotripsy and Other Methods of Removing Urinary Tract Stones

Urinary tract stones are a common health problem in the United States, affecting more than 10 percent of Americans at some time in their lives. The annual incidence of symptomatic stone disease is estimated to be approximately 1.2 per 1,000 for males and 0.36 per 1,000 in women. The incidence of stones is very low in the pediatric population, and reaches a peak between ages 30 to 60. Stones are three times more common in men than in women, and appear to be more common in whites than in other racial groups. Geographic variation in incidence is believed to be related partly to the hardness of drinking water, with hard-water areas (such as the Rocky Mountain states) having a lower incidence of stone disease than Southern states. While stone formation is sometimes associated with rare metabolic disorders, common risk factors are not well understood.

Urinary tract stones may be asymptomatic, but frequently result in severe pain (colic) and may cause infection, obstruction, and decreased renal function. The majority of symptomatic stones pass with conservative medical therapy consisting of high fluid intake and analgesia. However, technologic intervention is indicated when pain is prolonged or intolerable, or when the stone is associated with infection or causes obstruction of urine flow.

Physicians' options for technologic intervention in stone disease are evolving rapidly. For decades the standard procedure to remove stones was open surgery. In the late 1970s, endoscopic procedures became available to visualize directly and to remove stones from the

lower part of the urinary tract. In 1984 extracorporeal shock wave lithotripsy (ESWL) was approved in the U.S. as a method of crushing urinary tract stones with shock waves so that they either pass spontaneously or are more easily extracted through endoscopic procedures.

Most stone disease is managed by urologists. Once the decision is made to intervene technologically in stone disease, the urologist's choice of procedure(s) depends on many factors, including the size of the patient, the location and age of the stone, and coexisting medical conditions. Absolute contraindications to ESWL are obstruction, bleeding disorders, and pregnancy. ESWL is also more difficult to perform in markedly obese patients and when stones lie near bony structures. (In both cases, it is difficult to focus the shock waves on the stone.) For small stones in optimal position and without obstruction, ESWL alone may be the most appropriate procedure. For large stones and stones lying near bone, percutaneous or endoscopic procedures may be used to remove the stone or to debulk it and reposition it for later lithotripsy. Finally, lithotripsy may be used as an initial procedure and be followed by an endoscopic procedure to remove large fragments that fail to pass spontaneously.

In summary, urologists have several options in intervening in stone disease. Open surgical procedures are used with much less frequency today. Replacing them are percutaneous and endoscopic manipulation and extraction techniques, extracorporeal lithotripsy, and various combinations of these procedures.

It is understood that the newer technologies for stone disease are complementary, and that two procedures (such as endoscopy and ESWL) may now be performed in place of a single open surgical procedure. However, it is also likely that the lower morbidity caused by the newer procedures (when compared to open surgery) has led to a decrease in the number of stone patients who are managed medically, and to a further increase in the number of stone-related procedures. As one urologist (Riehle, 1989) wrote: "Patients' business schedules, their reluctance to endure colics if nonsurgical treatment is available, the generosity of the third party insurance system, and urologists' inclination to treat rather than observe all push toward the scheduling and occurrence of a technological event."

1.3 Executive Summary

1.3.1 Study Methods

Three groups of technologies were selected for analysis:

(1) coronary artery bypass graft (CABG) surgery and percutaneous transluminal coronary angioplasty (PTCA);

(2) CT scans of the head and magnetic resonance imaging (MRI) of the head; and

(3) surgical methods of extracting urinary stones and extracorporeal shock wave lithotripsy (ESWL).

The first technology in each group is a well-established procedure, expected to be already well-diffused in the Medicare population. The second technology in each group represents a relatively recent innovation that can serve as a full or partial substitute.

In order to study national utilization trends for these technologies, as well as to examine any changes in patient characteristics, we relied on the BMAD beneficiary files. These files provided a national five percent sample of all Medicare patients receiving each of these technologies. The study period began in 1985, when most carriers were on HCPCS, and ran through 1989, the most recent available year. Although relatively short, this time period was believed to have been a time of very active diffusion for the three newest technologies (PTCA, MRI, and ESWL).

We were also interested in the diffusion of these technologies across smaller geographic areas, like MSAs and rural areas. For this kind of analysis, the BMAD samples are too small and we relied on a unique data base: 100 percent Medicare physician claims data from eleven states for a slightly shorter four-year period (1985-1988). These claims were used to construct population-based utilization rates at the small area level for each

technology. The eleven states were: Alabama, Arizona, Connecticut, District of Columbia, Georgia, Kansas, New Jersey, Oklahoma, Oregon, Pennsylvania, and Washington.

1.3.2 Decomposition of Medicare Spending on Technology

Medicare Part B expenditures for the seven technologies almost doubled over the five-year period, from \$16.19 per eligible in 1985 to \$31.39 in 1989. For policy purposes, it is important to know whether this rapid growth in spending is being driven by increases in the number of procedures performed or in the price paid per procedure. To better understand this, we decomposed spending per eligible (\$/E) for each technology into its component parts as follows:

$$\$/E = U/E * S/U * \$/S$$

where U/E = users per eligible;
S/U = the number of services per user; and
\$/S = price per service.

Table 1-1 presents this decomposition by year for each of the seven technologies. Thus, the average Medicare outlay of \$15.96 per eligible for CABG surgery in 1989 is the product of 0.0039 (the fraction of eligibles receiving a CABG in 1989), 1.01 (the number of CABG operations per person receiving a CABG) and \$4,052 (the average allowed Part B charge per CABG procedure).

Spending per eligible grew rapidly for the three new technologies (PTCA, MRI, and ESWL), almost tripling in the case of MRI scans.* Although their rates of increase were relatively more modest, expenditures grew for the more-established technologies as well, with

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*Percent changes are calculated for the 1986-89 period for all technologies, given the exceedingly small 1985 outlays for the newer technologies (PTCA, MRI, and ESWL).

TABLE 1-1

DECOMPOSITION OF MEDICARE EXPENDITURE INCREASES

	$/E	U/E	S/U	$/S
CABG				
1985	$9.21	0.0024	1.04	$3,691
1986	11.23	0.0028	1.05	3,819
1987	13.76	0.0032	1.05	4,094
1988	14.13	0.0033	1.06	4,040
1989	15.96	0.0039	1.01	4,052
%Δ[a]	42.1%	39.3%	-3.8%	6.1%
PTCA				
1985	$0.89	0.0006	1.18	$1,256
1986	1.39	0.0009	1.18	1,312
1987	2.49	0.0015	1.22	1,361
1988	3.19	0.0018	1.26	1,406
1989	4.04	0.0023	1.24	1,417
%Δ[a]	190.6%	155.6%	5.1%	8.0%
CT SCANS				
1985	$5.43	0.0426	1.25	$102
1986	6.25	0.0467	1.24	108
1987	7.62	0.0513	1.28	116
1988	7.86	0.0512	1.29	119
1989	7.07	0.0533	1.30	102
%Δ[a]	13.1%	14.1%	4.8%	-5.6%
MRI				
1985	$0.02	0.00005	1.00	$366
1986	0.82	0.00195	1.04	403
1987	1.66	0.00431	1.06	364
1988	2.45	0.00649	1.06	356
1989	3.16	0.00922	1.09	314
%Δ[a]	285.4%	372.8%	4.8%	-22.1%
OPEN SURGICAL TECHNIQUES FOR STONE REMOVAL				
1985	$0.30	0.00028	1.08	$1,003
1986	0.20	0.00020	1.09	923
1987	0.13	0.00012	1.08	1,032
1988	0.09	0.00009	1.04	997
1989	0.10	0.00008	1.18	1,020
%Δ[a]	-50.0%	-60.0%	8.3%	10.5%
ENDOSCOPIC TECHNIQUES FOR STONE REMOVAL				
1985	$0.30	0.00069	1.15	$382
1986	0.36	0.00077	1.18	401
1987	0.48	0.00092	1.24	423
1988	0.57	0.00101	1.31	429
1989	0.61	0.00115	1.24	431
%Δ[a]	69.4%	49.4%	5.1%	7.5%
ESWL				
1985	$0.01	0.00002	1.04	$692
1986	0.30	0.00029	1.14	915
1987	0.51	0.00048	1.11	961
1988	0.51	0.00048	1.10	964
1989	0.65	0.00058	1.13	996
%Δ[a]	116.7%	100.0%	-0.9%	8.9%

[a] Percent changes were calculated for the 1986-1989 time period rather than the full five-years, due to the exceedingly small utilization rates in 1985.

Medicare outlays for CABG surgery 20 percent greater in 1989 than in 1986. Open surgical techniques for stone removal was the exception; spending was halved, as surgeons began to substitute other, less invasive, methods of stone removal. In all cases where expenditures grew, the spending increases were driven by the dramatic growth in user rates. By contrast, increased intensity (more services per user) and higher prices were generally far less important.

This growth in user rates is probably due to a wide range of factors, including diffusion of the technology itself and its greater acceptance by patients and physicians. Whatever the reasons, Medicare access to these high-technology services has improved dramatically. For policymakers, the sources of these increases imply that expenditure growth can be controlled only by controlling beneficiary access to services. Limits on service intensity (once the beneficiary already has entered the system) or on price would appear to play only a small role in limiting program outlays.

Several caveats should be mentioned, however. For certain technologies, our analysis may have underestimated the role of intensity or price. In the case of CABG and PTCA, for example, our measure of intensity (S/U) captures only repeat procedures during the same calendar year; given a mean elapsed time of over 12 months between the first and second bypass, for example, we have undercounted slightly the true number of procedures per user.

Furthermore, our measure of price ($/S) captures both shifts in procedure code mix and allowed charge updates over time. The physician fee freeze was in effect for almost the first third of this time-series (through May 1986 for participating physicians and December 1986 for non-participants). This obviously constrained the rate of increase in $/S for all of the technologies. In the case of CABG surgery, Medicare fees were reduced in many areas beginning in April 1988 (as part of the OBRA-87 overpriced procedure reductions). The introduction of a fee schedule for radiology at the same time seems to have also lowered average per procedure reimbursement for CT and MRI. Of course, absent the fee freeze and other payment reductions, total spending per eligible ($/E) would also have risen commensurately.

1.3.3 Black-White Differences in Utilization

A policy of cost control that restricts beneficiary access to new technologies rests on the assumption that those services can be rationed fairly and equitably. In particular, such a policy assumes that access will be based on patient need and not on other factors like race, income, or residence. Table 1-2, however, suggests that the current allocation of many technologies may be neither fair nor equitable by race. With one exception (CT scans), utilization rates for black Medicare eligibles are lower, sometimes substantially lower, than those for white eligibles.

Of particular interest are the trends for the two technologies used to treat coronary artery disease: CABG surgery and PTCA. A number of studies have documented the lower utilization of cardiac procedures by blacks (Ford et al., 1989; Graves and Haupt, 1983; Maynard et al., 1986; Wenneker et al., 1989); this is the first time (to our knowledge) that this has been shown specifically for Medicare patients. This is important, as unlike Medicaid and many private insurors, Medicare coverage and benefits are uniform across the country and across patient groups. Furthermore, despite rapid increases in utilization for both racial groups, the white-black differential has remained relatively constant across the five-year period. White Medicare eligibles undergo both CABG and PTCA at almost three times the rate as black Medicare eligibles, even though the incidence of coronary artery disease is probably equivalent for the two groups.

Both CT and MRI scans of the head are performed primarily in cases of suspected cancer, stroke, and trauma. The greater prevalence of stroke among blacks (Kittner, 1990) may partly explain their consistently higher CT utilization. If so, we would have expected MRI use to also be higher; instead, this newer technology is used disproportionately more on white Medicare eligibles. (The use "gap" appears to have narrowed considerably in 1989, however.) Since MRI is more expensive, and black Medicare patients are less likely to own supplemental Medi-Gap policies (Garfinkel, et al., 1987; Long, et al., 1982), racial differences in income may be one reason for the inconsistency in CT versus MRI utilization. Alternatively, this may simply be an artifact of the uneven geographic diffusion of MRI scanners.

TABLE 1-2

TRENDS IN TECHNOLOGY USE BY RACE (number of procedures per 1,000 eligibles)[a]

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
CABG						
White	2.69	3.17	3.65	3.90	4.29	35.3%
Black	0.68	0.93	1.22	1.21	1.58	69.9
PTCA						
White	0.79	1.10	2.04	2.46	3.16	187.3
Black	0.20	0.40	0.65	0.76	1.13	182.5
CT						
White	53.68	59.61	66.22	67.32	72.52	21.7
Black	62.59	70.92	79.68	83.60	92.30	30.1
MRI						
White	0.05	2.12	4.72	7.28	10.89	413.7
Black	0.02	1.21	3.23	4.94	9.09	651.2
OPEN STONE REMOVAL						
White	0.30	0.21	0.13	0.10	0.11	-47.6
Black	0.19	0.14	0.10	0.08	0.05	-64.3
ENDSOCOPIC STONE REMOVAL						
White	0.79	0.92	1.19	1.40	1.55	68.5
Black	0.50	0.61	0.68	1.00	0.97	59.0
ESWL						
White	0.02	0.34	0.56	0.55	0.72	111.8
Black	0.01	0.22	0.28	0.40	0.39	77.3

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[a] All rates have been adjusted for age and sex differences between white and black Medicare eligibles.

Source: BMAD beneficiary files, 1985-1989.

Although white Medicare eligibles also undergo both ESWL and other methods of stone extraction at higher rates compared with black eligibles, there is (limited) epidemiologic evidence to suggest a higher incidence of urinary stones among whites (Mulley, 1988). The racial disparities are also considerably smaller for this pair of technologies (both relatively and in terms of their absolute levels).

One possible explanation for these racial utilization differences is that black Medicare beneficiaries may be disproportionately located in rural areas, which have not yet adopted the newer technologies. Based on our eleven-state data base, however, there is no evidence that this is the case. Comparison of white and black utilization rates for urban and rural areas separately within the same state showed systematically higher rates for whites for all technologies except CT scans. For many states, the white-black "gap" was even larger than that observed for the U.S. as a whole. Table 1-3 compares CABG and PTCA trends in five large MSAs, all MSAs that also have high concentrations of black Medicare enrollees. White Medicare eligibles living in these cities are more likely to undergo bypass surgery and angioplasty than are black residents of the same cities. In Atlanta, for example, the use "gap" is over four-to-one for both technologies.

There are, of course, still other competing explanations for these racial differences in utilization, including:

- ***Ability-to-pay:*** Black Medicare eligibles are less likely to have any supplemental insurance for Part B copays (including both Medicaid and private Medi-Gap policies).
- ***Patient and Physician Attitudes:*** Black Medicare patients may be less willing to undergo invasive procedures, such as CABG and PTCA; alternatively, physicians may be less inclined to recommend these procedures to blacks.
- ***Disease Prevalence:*** Black-white differences in underlying disease prevalence and/or health status may be greater than previously believed.

While our analysis is unable to identify the reasons for these white-black differentials, they are significant and suggest that policymakers should carefully evaluate alternative utilization

TABLE 1-3

A TALE OF FIVE CITIES[a]

	CORONARY ARTERY BYPASS SURGERY				
	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
Atlanta, GA					
White	3.72	3.80	4.12	4.57	20.3%
Black	0.74	0.87	1.30	1.03	18.4
Birmingham, AL					
White	5.90	6.18	6.53	6.97	12.8
Black	1.56	1.43	1.96	1.87	30.8
Newark, NJ					
White	1.21	2.54	2.45	2.78	9.4
Black	0.56	0.80	0.76	1.06	32.5
Philadelphia, PA					
White	2.83	3.28	4.12	4.86	48.2
Black	0.98	1.03	1.46	1.53	48.5
Washington, D.C.					
White	3.32	2.96	2.97	3.58	20.9
Black	1.40	0.87	1.72	1.78	104.6

	PERCUTANEOUS TRANSLUMINAL CORONARY ANGIOPLASTY				
	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
Atlanta, GA					
White	1.12	2.06	2.41	3.58	73.8%
Black	0.46	0.59	0.58	0.78	32.2
Birmingham, AL					
White	0.84	1.33	3.65	4.12	209.8
Black	0.16	0.10	0.88	1.14	1,040.0
Newark, NJ					
White	0.37	0.76	1.21	1.72	126.3
Black	0.18	0.18	0.73	0.69	283.3
Philadelphia, PA					
White	0.69	1.07	1.46	2.05	91.6
Black	0.33	0.48	0.74	1.04	116.7
Washington, D.C.					
White	0.95	1.28	2.18	3.05	138.3
Black	0.31	0.38	0.79	1.43	276.3

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[a] All rates are users per 1,000 Medicare eligibles residing in these MSAs and have been adjusted for population age and sex differences.

Source: 100% Medicare Claims files.

control strategies for these technologies. In particular, the introduction of new financial barriers to access (e.g., higher copays) could have unintended consequences for black Medicare beneficiaries.

1.3.4 Diffusion of Technologies Across Urban and Rural Areas

Because new technologies are adopted first in large MSAs, many policy makers believe that residents of rural areas experience limited access to these technologies. Our results suggest that, while utilization rates are often lower in rural areas, they are not nearly so low as some observers might have expected (see Table 1-4). Furthermore, rates of increase over time are generally greater than those in urban areas.

While residents of MSAs are more likely to undergo CABG surgery compared with those living in rural areas, they are less likely to receive PTCA. In both cases, however, the differential is relatively small. Access to cardiac technology is essentially the same in both urban and rural areas.

Although urban utilization rates for CT and MRI scans are well above those in rural areas, the rural rates of increase are growing rapidly. MRI utilization rates for rural residents appear to be lagging only one to two years behind those for city-dwellers.

Finally, utilization rates for the newer stone extraction procedures (whether endoscopic or by lithotripsy) are actually higher in rural areas than in MSAs. One explanation may be the positive relationship of the softness of drinking water to the incidence of stone disease. Water in Southern states is believed to be considerably softer than in other areas; the Southern part of the country includes a disproportionately large rural population.

1.4 Overview of Report

Chapter 2 describes the data bases used in this analysis, and discusses the various methodological issues involved in constructing the analytic files. All analyses based on the national BMAD beneficiary files are presented in Chapter 3. This includes trends in

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TABLE 1-4

TRENDS IN TECHNOLOGY USE ACROSS URBAN AND RURAL AREAS (procedures per 1,000 eligibles)[a]

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
CABG						
Urban	2.54	2.97	3.41	3.49	3.83	29.0%
Rural	2.34	2.79	3.24	3.46	3.72	33.3
PTCA						
Urban	0.75	1.09	1.91	2.18	2.78	155.0
Rural	0.70	1.05	1.80	2.34	2.84	170.5
CT						
Urban	56.75	62.26	68.47	68.85	72.29	16.1
Rural	42.50	48.72	56.49	57.55	61.12	25.5
MRI						
Urban	0.05	2.35	5.22	7.77	11.07	371.1
Rural	0.04	1.17	2.84	4.50	7.25	519.7
OPEN STONE REMOVAL						
Urban	0.26	0.19	0.11	0.10	0.10	-47.4
Rural	0.35	0.24	0.15	0.09	0.10	-58.3
ENDOSCOPIC STONE REMOVAL						
Urban	0.75	0.85	1.11	1.27	1.34	57.6
Rural	0.80	0.93	1.10	1.36	1.57	68.8
ESWL						
Urban	0.02	0.32	0.53	0.52	0.64	100.0
Rural	0.02	0.33	0.53	0.55	0.68	106.1

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[a] All rates have been adjusted for age and sex differences across areas.

Source: BMAD beneficiary files, 1985-1989.

utilization and allowed charges, shifts in procedure code mix and location, differential use by age, race, gender, and location, as well as survival analysis (focusing on time to failure for certain procedures). Chapter 4 presents trends in utilization rates by state and by urban and rural areas within state, using the Multistate Data Base. Utilization rates for white and black Medicare eligibles residing in these same areas are compared in Chapter 5. Finally, we model the technology diffusion process using econometric techniques in Chapter 6.

Unlike most reports where tables accompany the text in which they are referenced, we have placed all tables at the end of the chapter to which they belong. Given the large number of tables relative to text narrative, we believe this will be less distracting to the reader.

2.0 DATA SOURCES

2.1 Study Period and Choice of Data Sources

The study period began in 1985 (when most carriers were on HCPCS and thus reporting uniform procedure codes) and ran through 1989. Although relatively short, this particular time period was believed to be a period of very active diffusion of the three newest technologies (PTCA, MRI, and ESWL). If so, then even five years should be sufficient to observe at least short-run trends in utilization.

This research employed several data bases. The 5 percent BMAD beneficiary file was linked with hospital admission (MEDPAR) and eligibility (HISKEW) information. This combined data base was used to study utilization and spending trends for the three groups of technologies at the national, regional, and state levels. This data base was also used to examine how competing technologies were used at the beneficiary level. In addition, we drew upon the special Multistate Data Base that the Center for Health Economics Research has constructed. This second large data base was used to study diffusion of these technologies at the market area level. (Only four years, 1985-1988, were available for this part of the study.) These data bases are described in detail below.

2.2 Data Sources for Analysis of Utilization and Substitution

The BMAD 5 percent beneficiary file was the data source for our analysis of national trends in utilization and substitution for these technologies. The first methodological issue to be solved was resampling beneficiaries with end-stage renal disease (ESRD). The 5 percent BMAD beneficiary file contains a 100 percent sample of beneficiaries who are eligible by virtue of ESRD. In order to obtain a nationally representative sample of all Medicare beneficiaries, a 5 percent sample of ESRD patients must be selected. This is easily done using the same selection criteria used by the carriers for other beneficiaries (i.e., based on

their social security number). This resampling technique was performed on all four years of our 5 percent BMAD beneficiary files before further analysis was undertaken.

From the beneficiary files for 1985-1989, we next identified all Part B (physician) claims for the procedure codes shown in Tables 2-1, 2-2, and 2-3. Seven editions of CPT-4 manuals (1984 to 1990) were reviewed to insure that all procedure codes for the selected technologies were included in our study. (It was important to check the 1984 edition since some physicians and carriers may be using older codes. It is also possible that 1989 claims will contain codes from the 1990 CPT-4 manual, since this edition became available in November 1989.) We also identified and included any carrier-level procedure codes relevant to the technologies in this study. These Part B claims for the technologies were abstracted from the BMAD files and "cleaned" using a standard set of edits (described in Section 2.5 below). Local codes were converted to CPT-4 codes during file-cleaning.

A sorted list of unduplicated HIC numbers was then used to obtain all hospital admissions from the MEDPAR files for 1985-1989 for beneficiaries in the 5 percent BMAD sample who received one or more of the high-cost technologies selected for study. The HISKEW (eligibility) records of these beneficiaries was obtained in a similar manner. Each of the three data sources (HISKEW records, Part A and Part B claims) were sorted by HIC number. Part A claims were also sorted by admission date, and Part B claims were sorted by date of service. The three data sources were then merged into beneficiary-level records, each record containing relevant data for a single beneficiary for the five-year study period.

Seven separate beneficiary-level files were constructed from our data sources. Each file was identical in construction, but contained a different range of technologies. File One (CABG) includes all beneficiaries who had one or more CABG procedures during the study period. Each beneficiary-level record in File One includes:

- HISKEW data, including date of birth, sex, race, county and state of residence, reason for Medicare eligibility, and date of death if deceased;

- Part A hospital claims data, including dates of admission and discharge for up to seven/ hospital admissions during the study period, regardless of reason for admission, together with lengths of stay, DRG codes, and three surgical procedure codes and five diagnostic codes for each admission;

- Part B physician claims data, including date of service, physician identifier, procedure code, modifier, carrier and charge data for up to ten/ physician claims for CABG procedures and for PTCA (the competing technology).

Thus, File One contains data on all beneficiaries who had CABGs and includes PTCA claims for the small number of CABG patients who also underwent PTCA. File Two (PTCA) is similarly constructed, but contains data on all beneficiaries who underwent PTCA and includes CABG claims for the minority of PTCA patients who also received CABGs. Files Three through Seven contain similar data for the remaining two groups of competing technologies (CT versus MRI scans; and ESWL versus open versus endoscopic stone extraction procedures).

The merged records were then used to describe the sociodemographic characteristics of Medicare beneficiaries who use these technologies, and to determine if these characteristics are changing over time. These merged files allowed us to count both the number of procedures within each technology and the number of users of each technology. We were thus able to decompose the observed growth in utilization for each technology into changes in intensity (procedures per user) and changes in the number of users. Additionally, we analyzed data for each beneficiary to determine the proportion who received multiple services within a technology pair (e.g., MRI and/or CT scans) during a single "episode of illness," defined as a specific time interval since the beneficiary's initial procedure. Finally, since our merged data base contained all Medicare hospital claims for beneficiaries in the sample, we were able to determine the principal and secondary diagnoses for beneficiaries hospitalized during the same episode of illness as a head CT or MRI scan. (We did not examine diagnoses for beneficiaries receiving CABG, PTCA, lithotripsy, or other stone procedures since the indications for these procedures are self-evident.)

2.3 Data Sources for Analysis of Technology Diffusion

Except in the case of very large areas, the five percent BMAD beneficiary file is too small to adequately support an analysis of technology diffusion. Consider Portland (Oregon), for example. The five percent beneficiary sample would yield only three or four MRI scans, and four or five CABG operations (based on observed 1986 rates). Equivalent numbers in other Oregon MSAs and non-MSAs would be even smaller.

As part of several ongoing HCFA-funded studies, we have assembled a unique data base: 100 percent Medicare claims from 11 states. The Part B claims have been obtained directly from the carriers and merged with HISKEW eligibility data obtained from HCFA. The eleven states are: Alabama, Arizona, Connecticut, District of Columbia, Georgia, Kansas, New Jersey, Oklahoma, Oregon, Pennsylvania, and Washington. These states were chosen to represent the nine census divisions as well as a range of urban and rural areas.* Together, they account for almost 25 percent of all Medicare beneficiaries. Data were available for four of the same five-years as the BMAD data: 1985 - 1988.

Because of their sheer volume (over 100 million physician claims per year), analyzing these data can be very expensive. Therefore, we constructed a file which aggregated data at the area level for each of the four years. There are 95 areas representing a mix of MSAs, other urban, and rural areas. "Other urban" areas are counties which, while not part of an MSA, contained towns with populations of 25,000 or more. Examples include Selma, Alabama and Walla Walla, Washington. All expenditure and utilization data are population-based, i.e., calculated for the Medicare eligible population that resides in the area, regardless of where they seek care. Detailed information was retained on spending and use of physician services for the six procedures (CABG, PTCA, CT, MRI, stone removal procedures, and ESWL). Utilization and expenditure data were summarized in cells that are

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*A twelfth state, Wisconsin, was originally included in the study. Unfortunately, this state had to be dropped in its entirety, from the trend analyses, as the 1988 claims received from the carrier were incomplete. Wisconsin was included in the econometric analyses, however, as these analyses did not use all four year of data.

determined by a unique combination of age, sex, race, location of service, and assignment status within each of the areas. All rates were then adjusted for population age and sex differences based on national Medicare enrollment data (see Section 2.5.3).

Because Part B claims were available only for the evelen states under study, it was possible that technology use could be underestimated for those areas in which residents routinely travel out-of-state for care. We were able to obtain all Part A claims for residents of our states, however, regardless of where they were actually hospitalized. We examined out-of-state admissions separately for each county in our states. If out-of-state admissions represented 15 percent or more of the county's total hospitalizations, those counties were deleted from the analysis. These were primarily rural counties, although in a few cases they were counties that were part of a larger MSA across the state border (e.g., several Wisconsin counties were part of the Minneapolis MSA). Since Medicare patients are more likely to travel out-of-state for hospital care than for ambulatory physician services, our adjustment should minimize any potential underestimates of technology use.

In order to provide descriptive statistics on our geographic areas, we merged selected data elements from the March 1990 release of the Area Resource File (ARF). In order to do this, a crosswalk was created to match the county-level ARF data with each of the 95 area groupings. Selected ARF variables included: physician supply, hospital/nursing home/HMO supply, population, and socioeconomic characteristics, such as per capita income.

2.4 Denominator Data

Our Multistate claims-based files obviously provide information only on users of services. In order to calculate rates of use, we need information on the number of Part B enrollees residing in each of our geographic areas. Furthermore, in order to adjust for underlying age and sex differences across areas, we also need to know the distribution of enrollees across age-sex cells for the same areas. This information constitutes the denominator for our rate calculations.

HCFA provided us with their "denominator files" for each of the study years, essentially a census of all Medicare eligibles in the U.S. This file includes demographic data (age, sex, race, location), as well as detailed information by calendar month on Part A and Part B eligibility, as well as HMO enrollment. These files were used in two ways: (1) to construct denominator data corresponding to each of the 95 areas created from the Multistate Data Base; and (2) to construct a 5 percent sample of enrollees, corresponding to the BMAD beneficiary file.

The denominators for the 95 areas were calculated by identifying those Part B enrollees living in each area. Since many enrollees are eligible for only part of the year (due to death or other changes in eligibility status), we summed the number of eligible months and divided by 12. This provided us with a measure of eligible-person years. Any months enrolled in an HMO were dropped from the denominator, as were all railroad retirees. (Our claims data included only those beneficiaries whose claims were processed by their respective state's carrier, and excluded railroad retirees whose claims are handled by a separate national carrier.)

For the BMAD analyses, we created a five percent sample of Part B enrollees, using the same sample selection criteria with the denominator file as had been used for sampling BMAD records. Eligible person-years were then calculated in the same way as for the Multistate Data Base, but with one exception; since the BMAD files include railroad retirees, we also retained this group in the denominator.

2.5 Methodological Issues

2.5.1 Eliminating Duplicate and Reprocessed Claims

Before analyzing claims data from the 5 percent BMAD file and from the 100 percent Multistate File, several methodological issues had to be resolved. Claims files present the possible hazard of overestimation of utilization and costs because of the presence of duplicate claims for the same service. The primary source of duplicate claims is the process of

adjusting or reprocessing claims that are initially denied or underpaid. Physicians may challenge the denials or low payments. If the appeal is successful, a second claim is usually generated that reflects the same procedure and date of service, but with a different date of payment and a different allowed charge. This "reprocessed" claim thus represents the identical physician service as the original, but is not an exact duplicate of the original claim. Since claims reprocessing procedures vary by carrier, we have developed carrier-specific methods for detecting and eliminating (or combining, where appropriate) original/reprocessed claim pairs that might lead to utilization and cost overestimates. All such file cleaning was performed prior to analysis, for both the 5 percent BMAD and the 100 percent Multistate files.

2.5.2 Appropriate Use of Modifiers

A second methodological issue to be resolved deals with the use of modifiers that indicate the level of service provided by a physician. This issue is especially important when analyzing two types of physician services: surgical procedures (such as CABG and PTCA) and special tests and radiology (such as CT and MRI scans). In analyzing surgical claims, we usually are interested in the primary surgeon's claim, and want to omit from analysis the claims of co-surgeons, assistant surgeons, and physicians' assistants. CPT-4 and HCPCS coding schemes contain procedure code modifiers which allow assistants to describe their level of service appropriately. If such modifiers were used consistently, it would be a simple matter to eliminate co-and assistant surgeons' claims from analytic files. However, these surgeons commonly omit all modifiers from their claims; assistance at surgery can be inferred only from a lower submitted and allowed charge, compared to a similar claim with the same date of service submitted by the primary surgeon. Although difficult and time-consuming, distinguishing these "helper" claims is important. In areas where all CABG procedures have claims for both primary and assistant surgeons, simply counting the number of claims for CABG procedures would double the estimate of CABG utilization and greatly inflate the expenditure estimates.

All radiologic procedures (as well as some other diagnostic services, such as ECGs) have two billable components. The first is the technical component: positioning the patient, obtaining the radiographic image, and so forth. This component is frequently performed by a technician who is employed by a physician or a hospital. If the technical component is performed using hospital staff and equipment, it is billed as a Medicare Part A service.

The second component of the service is the professional component: interpreting the X-ray image. Interpretation is always performed by a physician and billed to Medicare under Part B. However, physicians may bill for the complete procedure if they or their staff perform both the technical and professional components of the service.

Of course, reimbursement varies substantially depending on whether the bill represents the technical, the professional, or both components of the service. CPT-4 and HCPCS coding systems allow providers to indicate the level of service through the use of procedure code modifiers. Generally, "TC" is used to indicate the technical component, "26" indicates the professional component (interpretation), and a blank modifier indicates that both components are being billed.

For CT and MRI claims, perhaps the most frequent coding error occurs when physicians interpret scans performed in hospital inpatient or ambulatory settings. In these cases, the physician's submitted charge clearly indicates that only the interpretation is being billed; however, the procedure code modifier is typically blank rather than "26." This common coding error would greatly distort our estimates of CT and MRI utilization and reimbursement by level of service. We therefore forced the modifier to "26" (interpretation only) for all CT and MRI scans performed in inpatient and hospital OPD settings. Modifiers for scans performed in all other locations were kept as they appeared on the original claim.

2.5.3 Recoding of Level III Local Codes

An important methodological issue is the consideration of carrier-specific Level III codes. If a carrier is routinely coding any of these technologies as Level III codes, it

may bias the results downward for that carrier. We reviewed the HCFA Level III code listing looking for any codes relating to these technologies. The few such codes that were found were converted to CPT-4 by a certified medical records technician.

2.5.4 Adjusting For Population Age and Sex Differences

In order to validly compare utilization rates across areas, it is important to first adjust for any underlying age and sex differences in the Medicare populations. We did this using the traditional direct method. Utilization rates were calculated for eight age-sex cells: 2 sex * 4 age groups (less than 65, 65-74, 75-84, and 85+). These rates were then weighted by the national proportion of Medicare eligibles in each of these cells in order to obtain a single, adjusted, rate at the area level.

Because the BMAD sample is drawn randomly, it is self-weighting and no age-sex adjustment is necessary. When we make comparisons between subgroups, however, we then need to use the direct method again to adjust for age-sex differences between the groups, e.g. for black versus white eligibles.

2.5.5 Use of Survival Analysis For Technology Substitution

In this project, we wanted to examine the extent to which technologies within a pair are used jointly or as substitutions for one another. For some types of technology (e.g, CT and MRI scans), it is appropriate to define a typical "episode of illness" (approximately 30 to 60 days) and to count the number of beneficiaries who received two or more scans within an episode of illness. For technologies such as CABG and PTCA, it is difficult to define an episode of illness: coronary artery disease is a lifelong process. We therefore chose to use survival analysis techniques to examine the "time to failure" for initial CABGs or PTCAs and to study various factors (such as age, gender, or number of grafts in the initial CABG) which might influence the choice of the second procedure. Since the number of PTCAs performed under Medicare was increasing rapidly during our study period, survival analysis offered

the advantage of overcoming possible bias due to differences in follow-up time (CABGs being more likely to have longer follow-up time). Since we were interested in only a small number of covariates (e.g., age, gender, and number of grafts), the product-limit or Kaplan-Meier approach to survival analysis was selected (Cox and Oakes, 1984). A competing-risk version of the product-limit approach was employed for analysis of type of second procedure (CABG or PTCA), given type of first procedure (CABG or PTCA). Model fitting was done using PROC LIFETEST in SAS (SAS Institute, 1988a).

To gain some insight into potential confounding among the predictor variables, survival analysis was supplemented with estimation of year- and covariate-specific estimates of per-capita incidences of each procedure. For example, the incidence of PTCA in each of several age groups in each year of the study was estimated so that changes in PTCA incidence among age groups could be examined. Contingency tables and loglinear analysis (Bishop, Feinberg, and Holland, 1975) were also employed to examine the associations among predictors and, in preliminary steps, between the predictors and certain outcomes. For example, the number of vessels involved in a PTCA was compared with the number of vessels or grafts in a CABG. For each procedure, the number of vessels involved was compared across genders. PROC FREQ of SAS (SAS Institute, 1988b) was used for the cross tabulations, while the 4F program of BDMP (Dixon 1990) was used to fit the loglinear models.

TABLE 2-1

CPT-4 PROCEDURE CODES FOR CORONARY ARTERY BYPASS SURGERY (CABG) AND FOR PERCUTANEOUS TRANSLUMINAL CORONARY ANGIOPLASTY (PTCA)

CPT-4 CODE	*DESCRIPTION*
33510	Coronary artery bypass, autogenous graft (e.g., vein or IM artery); single graft
33511	Two coronary grafts
33512	Three coronary grafts
33513	Four coronary grafts
33514	Five coronary grafts
33516	Six or more coronary grafts
33520	Coronary artery bypass, nonautogenous graft (e.g., synthetic or cadaver); single graft
33525	Two coronary grafts
33528	Three or more coronary grafts
33570	Coronary angioplasty (endarterectomy with or without gas, arterial implantation or anastomosis), with bypass
33575	Combined with vascularization
92982[a]	Percutaneous transluminal coronary angioplasty; single vessel
92984[a]	Each additional vessel
93570[b]	Percutaneous transluminal coronary angioplasty; single vessel

[a] New code in 1986 edition of CPT-4 (published November 1985).

[b] Code deleted after 1985 edition of CPT-4.

Source: American Medical Association, Physicians' Current Procedural Terminology (CPT-4), Chicago: American Medical Association, 1984-1989.

TABLE 2-2

CPT-4 PROCEDURE CODES FOR COMPUTERIZED AXIAL TOMOGRAPHY (CT SCANS) AND MAGNETIC RESONANCE IMAGING (MRI SCANS) OF THE HEAD

CPT-4 CODE	*DESCRIPTION*
70450*	Computerized axial tomography, head; without contrast material
70460*	With contrast material(s)
70470*	Without contrast material, followed by contrast material(s) and further sections
70480	Computerized axial tomography, orbit, sella, or posterior fossa or outer, middle, or inner ear; without contrast material
70481	With contrast material(s)
70482	Without ontrast material, followed by contrast material(s) and further sections
76375	Computerized tomography, coronal, sagittal and/or oblique reconstruction (if done on same day as CT of head)
70540[a]	Magnetic resonance (e.g., proton) imaging; orbit, face, and neck
70550[b]	Magnetic resonance (e.g., proton) imaging; brain
70551[a]	Magnetic resonance (e.g., proton) imaging; brain (including brain stem)
70552[b]	Magnetic resonance (e.g., proton) imaging; brain stem

*In 1985 edition of CPT-4, this code reads "...head or brain"; later editions read "...head."

[a] New code in 1986 edition of CPT-4 (published November 1985).

[b] Code was used only in the 1985 edition of CPT-4 (published November 1984).

Source: American Medical Association, Physicians' Current Procedural Terminology (CPT-4), Chicago: American Medical Association, 1984-1989.

TABLE 2-3

CPT-4 PROCEDURE CODES FOR EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY (ESWL) AND OTHER SURGICAL PROCEDURES FOR ELIMINATING STONES FROM THE URINARY TRACT

CPT-4 CODE	*DESCRIPTION*
Lithotripsy	
50590	Lithotripsy, extracorporeal shock wave
Open Surgery	
50060	Nephrolithotomy; removal of calculus
50065	Secondary surgical operation for calculus
50070	Complicated by congenital kidney abnormality
50075	Removal of large staghorn calculus filling renal pelvis and calyces (including anatrophic pyelolithotomy)
50130	Pyelotomy; with removal of calculus (pyelolithomy, pelviolithotomy, including coagulum pyelolithotomy)
50610	Ureterolithotomy; upper one-third of ureter
50620	Middle one-third of ureter
50630	Lower one-third of ureter
51060	Transvesical ureterolithotomy
51065	Cystotomy, with stone basket extraction and/or ultrasonic or electrohydraulic fragmentation of ureteral calculus
Endoscopy	
50080	Percutaneous nephrostolithotomy or pyelostolithotomy, with or without endoscopy, lithotripsy, stenting or basket extraction
50081	Over 2 cm
50560	Renal endoscopy through established nephrostomy or pyelostomy, with removal of foreign body or calculus, hospital
50561	Office [50560 was deleted in 1985 CPT-4; 50561 is then used for hospital and office)
50580	Renal endoscopy through nephrotomy or pyelotomy, with removal of foreign body or calculus
50961	Ureteral endoscopy through established ureterostomy, with removal of foreign body or calculus
50980	Ureteral endoscopy through ureterostomy, with removal of foreign body or calculus

TABLE 2-3 (continued)

CPT-4 PROCEDURE CODES FOR EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY (ESWL) AND OTHER SURGICAL PROCEDURES FOR ELIMINATING STONES FROM THE URINARY TRACT

	CPT-4 CODE	*DESCRIPTION*
Endoscopy (continued)		
	52310	Cystourethroscopy, with removal of foreign body or calculus from urethra or bladder; simple
	52315	Complicated
	52320	Cystourethroscopy (including ureteral catheterization); with removal of ureteral calculus
	52325	With fragmentation of ureteral calculus (e.g., ultrasonic or electro-hydraulic technique)
	52330	With manipulation [of ureteral calculus], without removal of ureteral calculus
	52336	Cystourethroscopy, with ureteroscopy and/or pyeloscopy, with removal or manipulation of calculus
	52337	With lithotripsy

Source: American Medical Association, Physicians' Current Procedural Terminology (CPT-4), Chicago: American Medical Association, 1984-1989.

3.0 ANALYSIS OF NATIONAL TRENDS IN UTILIZATION AND DIFFUSION

This chapter presents national trend data for the three groups of technologies, based on the BMAD beneficiary file samples. Data are presented for each of the five years in our study. However, because the low utilization rates in 1985 produce fairly unstable percent change estimates for the three new technologies (PTCA, MRI, and ESWL), percent changes (in utilization rates and the like) are calculated for the 1986-89 period only, for all technologies.

3.1 Coronary Artery Bypass Graft (CABG) Surgery and Percutaneous Transluminal Coronary Angioplasty (PTCA)

3.1.1 Utilization of CABG and PTCA Procedures

CABG surgery has been available for over twenty years, and its geographical diffusion in the United States is believed to be nearly complete. However, utilization of the technology continues to grow, especially among the elderly. The absolute number of CABG procedures performed on Medicare beneficiaries increased by 37.6 percent between 1986 and 1989 (Table 3-1). This represents a large increase in users over time, since the number of CABG procedures per user per year is essentially one. The total Medicare utilization rate for CABGs increased by 32.1 percent over the four-year period, from 2.93 to 3.87 procedures per 1,000 beneficiaries.

The number of grafts per procedure remained stable during the study period (Table 3-2). More than half of CABG patients received three or four grafts. Almost all procedures (99%+) used autogenous grafts (saphenous vein or internal mammary artery) rather than synthetic or cadaverous grafts. (For this reason, data for non-autogenous grafts - procedure codes 33520 through 33528 - are omitted from most of the following tables.)

Mean allowed charges for CABGs are shown by procedure code and year of service in Table 3-3. Overall, mean reimbursement per procedure increased 6.1 percent. A slight decrease in the average allowed charge is seen between 1987 and 1988 for all procedure codes, undoubtedly representing the effect of the OBRA-87 fee rollback for overpriced procedures (which went into effect April 1, 1988).

PTCA has been available since 1977, but still appeared to be diffusing rapidly during our study period. The number of PTCAs under Medicare nearly tripled between 1986 and 1989 (Table 3-4). Most of this change represented an increase in the number of users per year, since the number of procedures per user per year increased only slightly (from 1.18 in 1986 to 1.24 in 1989). The total Medicare utilization rate for PTCA increased by 164 percent, from 1.08 to 2.85 procedures per 1,000 beneficiaries. The PTCA utilization rate was three-fourths of the CABG rate (3.87 per 1,000) in 1989.

PTCA has been used primarily in patients with single-vessel disease. However, between 1986 and 1989 the number of claims for "additional vessels" (code 92984) increased from 4 percent to 9 percent of total PTCA claims. (Data for 1985 are not quite comparable since CPT-4 procedure codes for PTCA were changed during that year.) Nevertheless, 91 percent of PTCA procedures in 1989 were single-vessel procedures, while only 6 percent of CABG patients had single-graft procedures.

The mean allowed charge for single-vessel PTCA (code 92982) increased 11.6 percent over four years (Table 3-5). Charge data for code 92984 should be viewed as unstable, given the very small number of claims in both 1985 and 1986. Given the increased number of procedures in which a second vessel was angioplastied at an additional (albeit lower) charge, the average bill per treatment grew by 13.2 percent from 1986 to 1989. (By contrast, the mean allowed charge per vessel rose by only 8 percent.)

3.1.2 Specialties of Physicians Performing CABG and PTCA

Distribution of specialties for physicians performing CABG and PTCA was similar for all 5 years of the study. Thoracic surgeons were the primary surgeons for 67 percent of CABG procedures. Cardiovascular specialists were the primary surgeons for 16 percent. (Medicare's cardiovascular category includes both cardiologists and some cardiothoracic surgeons.) General surgeons performed less than nine percent of CABG procedures. In contrast, 69 percent of PTCAs were performed by cardiovascular specialists, with internists providing another 14 percent. Thoracic surgeons performed only 8 percent of PTCAs.

3.1.3 Sociodemographic Characteristics of Medicare Beneficiaries Receiving CABG and PTCA Procedures

The mean age of beneficiaries receiving CABGs is about 70, increasing only slightly during the study period (from 69.8 to 71.2 years). Utilization rates differed markedly among segments of the Medicare population (Table 3-6). The age-adjusted rate for males was nearly three times that for females. The rate for whites was approximately three times that for blacks, even after adjusting for age and sex differences in Medicare eligibility. Note that the rates of increase in CABG utilization rates are higher for blacks (69.9%) compared to whites (35.3%). Of course, the higher rate of increase for black Medicare eligibles is partly an artifact of the low absolute level to start with. Furthermore, even by 1989, differences in utilization by gender and race remained substantial.

The mean age of beneficiaries receiving PTCA increased from 67.6 to 71.1 years; by 1989, mean age was similar for CABG and PTCA patients. The age-adjusted PTCA utilization rate for males is approximately twice that of females (see Table 3-7). After correcting for age and sex differences among Medicare beneficiaries, the rate for whites is three times that of blacks, a race "gap" that is virtually identical to that shown earlier for CABG surgery.

The observed sex and race differences in CABG and PTCA utilization rates deserve comment. Men have a higher incidence of coronary artery disease (CAD) than do women, with men showing two to four times the CAD mortality rate of women in most industrialized countries (Syme and Guralnik, 1987). The higher rate of CAD procedures among male Medicare beneficiaries, therefore, is most likely explained by higher prevalence of CAD.

The large differences in utilization rates between races are far more difficult to explain. Published reports on the incidence of coronary artery disease in blacks are confusing and contradictory. However, careful review of the epidemiologic literature suggests that the incidence of CAD in blacks and whites is roughly similar (Gillum, 1982; Meyers, 1986). Racial differences in incidence are certainly inadequate to explain the threefold difference in CABG

and PTCA utilization rates between whites and blacks. Other studies have documented that blacks are much less likely to undergo coronary angiography and CABG surgery than are whites (Graves and Haupt, 1983; Maynard et al., 1986; Ford et al., 1989; Wenneker and Epstein, 1989). One recent study found a significant association between payor status and utilization of cardiac procedures (Wenneker, Weissman, Epstein, 1990), with the uninsured and Medicaid patients least likely to receive such treatments. The importance of our findings is that even after controlling for insurance coverage (all beneficiaries in our study were enrolled in Medicare Part B), large differences in utilization of these procedures persist. Since incidence and insurance coverage do not explain utilization differences, we must examine other possibilities. Two areas which remain to be explored are:

- sociocultural influences on physician and patient decision-making with regard to invasive procedures and surgery, and
- differences in access to expensive medical technologies based on geography and socioeconomic status.

3.1.4 Time to Failure for CABG and PTCA Procedures

Introduction

One of our primary goals in analyzing these technologies was to determine the ways in which competing technologies substitute for one another or are used jointly or sequentially in the same patient. For example, we wanted to learn whether patients with coronary artery disease frequently receive both CABG and PTCA procedures, and if so, whether PTCA (the less invasive procedure) typically preceded the other. We also wanted to determine the apparent time to failure of the first procedure in patients who received more than one treatment for CAD during our study period.

Coronary artery disease is a chronic disease that is usually progressive. Although the course of CAD may be punctuated by acute events such as myocardial infarction or episodes of congestive failure, it is difficult to discern discrete "episodes" of CAD itself. We therefore examined the entire five-year claims history for each Medicare beneficiary who

underwent a CABG or PTCA. We used survival analysis as a technique for examining the need for repeat treatments for coronary artery disease. Although this analytic technique uses the terms "survival curve" and "failure," we must emphasize that we cannot determine the failure of a specific procedure from claims data. A patient who undergoes a PTCA in 1986 and a CABG in 1988 may have had different vessels treated. The 1988 CABG is evidence of the need for retreatment, but does not necessarily indicate that the vessel treated in 1986 has become obstructed. When we use the terms "survival" and "failure" in this context, therefore, we are simply speaking of the need for retreatment for CAD.

We included in our analysis all beneficiaries who underwent a CABG or PTCA during our five-year study period. The mean follow-up time for all beneficiaries receiving CABG as a first procedure was 2.0 years, with a maximum follow-up of 5.0 years. The mean follow-up time for beneficiaries with PTCA as a first procedure was 1.3 years, with a maximum follow-up of 5.0 years.

Short-Term Failure Rates

Of all sampled beneficiaries whose first procedure for CAD was a CABG, only 2.1 percent received a second procedure during a mean follow-up period of 2 years (Table 3-8). Twenty-three percent of these repeat procedures occurred within seven days of the initial procedure; we call these short-term failures (See Table 3-9). That is, 0.5 percent (22.6 percent of 2.1 percent) of all Medicare beneficiaries receiving initial CABG procedures received a subsequent CABG or PTCA within seven days. Seventy-eight percent of these immediate repeat procedures were CABGs.

Of those beneficiaries whose first CAD procedure was PTCA, however, almost one-third (33.6 %) received a second procedure during a mean follow-up of 1.3 years (Table 3-8). Forty-nine percent of the repeat procedures were performed within seven days of the first PTCA. That is, 16.6 percent of Medicare beneficiaries receiving PTCA as an initial procedure for CAD received a subsequent CABG or PTCA within seven days (shown on Table 3-9). More than half (62.4%) of these immediate repeat procedures were PTCAs. Of course,

not all of these repeat PTCAs indicate unsuccessful initial procedures. When more than one vessel is to be treated, physicians may elect to perform angioplasty in stages, treating a single vessel per day. If we assume that all repeat PTCAs within seven days were planned staged procedures (rather than indications of unsuccessful initial PTCAs), then the apparent overall failure rate for PTCA is reduced from 33.6 to 23.2 percent.

Long-Term Failure Rates

We wanted to analyze the long-term as well as the short-term failure rates of CABG and PTCA procedures. We therefore recoded patients who received repeat procedures within seven days of an initial PTCA or CABG. Thus, for the purposes of long-term follow-up, a patient who received a PTCA, followed by a CABG within seven days, would be considered to have had an initial CABG procedure. The PTCA procedure would be considered to have failed, and the CABG becomes the index procedure. In cases where a beneficiary received both a PTCA and a CABG on the same day, we assumed that PTCA was the first-attempted and failed procedure, and considered the patient to have had a CABG for purposes of long-term follow-up.

Disregarding patients with immediate failures, then, 1.7 percent of Medicare beneficiaries receiving CABGs required subsequent CABG or PTCA procedures based on a mean follow-up of 2.0 years (see Table 3-10). Sixty-four percent of these patients received PTCA as the second procedure. After disregarding immediate failures, 20.3 percent of PTCA patients received subsequent CABG or PTCA procedures (mean follow-up 1.5 years). About 68 percent of these subsequent procedures were PTCAs.

Time to Failure By Type of First Procedure

We used a product-limit estimator of survival (part of the SAS survival analysis utility, PROC LIFETEST) to analyze factors related to repeat treatments (CABG or PTCA) for coronary artery disease. First, we used those patients whose index procedure was a CABG, after disregarding procedures that had "failed" within seven days. We wanted to determine whether patients with initial CABGs were more likely to undergo one type of procedure (e.g.,

PTCA) earlier than another (e.g., CABG). This might happen, for example, if patients and treating physicians had lower thresholds for performing PTCA than for CABG. In this analysis, we viewed repeat CABGs and repeat PTCAs as competing risks. We compared the survival curves for two groups of patients: those whose first observed procedure was a CABG and whose second procedure was also a CABG, versus those with an initial CABG and a subsequent PTCA. In analyzing time from first to second CABG, patients were considered to be right-censored if they had died, if they had received a PTCA as a second procedure, or when the study period ended. In analyzing time from CABG to PTCA, patients were considered to be right-censored if they had received a CABG, as well as if they had died, or when the study period ended.

Even after disregarding repeat procedures within seven days of the first CABG, there was a clear difference in the failure rates of the initial CABG procedure, depending on whether the second procedure was a PTCA or a second CABG. These differences in failure rates are shown in Figure 3-1. Two survival curves are shown for patients with CABG as a first procedure: one for those whose second procedure was also a CABG (curve A), and one for those whose second procedure was a PTCA (curve B). From about 150 days after the initial CABG, patients having PTCA as a second procedure had a higher failure rate (more rapidly decreasing survival curve) than did those whose second procedure was a CABG; the survival curves continued to diverge with increasing length of follow-up. Although differences between these curves appear small, they are significant: both the Wilcoxon and log-rank tests were significant at the 0.001 level. In other words, the nature of the second procedure (CABG or PTCA) is strongly associated with the time to the second procedure. One possible explanation for this difference is that physicians do have a lower threshold for performing PTCA in patients who have already undergone CABG procedures, at least in the Medicare population.

We repeated the analysis, this time comparing PTCA patients whose second procedure was a PTCA. Figure 3-1 also shows the survival curves (C and D) for these two groups. Again, we found that the survival curves clearly differed for the two groups, beginning at about 100 days after the first PTCA and continuing to diverge with increasing follow-up, a

higher failure rate (lower survival curve) being associated with having PTCA as a second procedure (curve D). The Wilcoxon and log-rank tests were both significant at 0.0001. These results give the impression that, at least in the Medicare population, physicians have a lower threshold for performing PTCA as a second procedure, regardless of whether the first procedure is a CABG or PTCA.

However, the most striking comparison is between patients with CABG as a first procedure and those with PTCA as a first procedure. The failure rate for PTCA patients (curves C and D) is clearly higher than for CABG patients (curves A and B), regardless of the nature of the second procedure. These survival curves illustrate the differences in overall failure rates for CABG and PTCA (Table 3-8): 2.1 percent for CABG (mean follow-up 2.0 years), versus 33.6 percent for PTCA (mean follow-up 1.3 years). Since our study did not control for severity of illness among CABG and PTCA patients, it is possible that PTCA patients had more severe coronary artery disease and might therefore have required additional surgical procedures, contributing to an apparently higher "failure" rate for PTCA in our study. However, our findings coincide closely with clinical studies showing restenosis ("true" failure) rates of up to 35 percent for angioplastied vessels (McBride, 1988).

Effect of Number of Grafts on Time to Failure

We also wanted to determine whether the time to second procedure was influenced by the number of grafts inserted during the initial CABG procedure. We placed all beneficiaries with initial CABGs into one of three groups, based on the number of grafts indicated by the CPT-4 procedure code: 1-2 grafts, 3-4 grafts, or 5 or more grafts. Survival analysis showed that the fewer grafts inserted during the initial CABG procedure, the earlier the second coronary artery procedure occurred, regardless of whether the second procedure was PTCA or a repeat CABG. The effect of number of grafts was more pronounced, however, when the second procedure was a PTCA. (The Wilcoxon test statistic was significant for both groups, but the log-rank was significant only for those with PTCA as a second procedure). This effect has several possible interpretations. First, it is conceivable that more aggressive early CABG surgery decreases the need for later intervention. Alternatively, it is equally possible that

patients with more aggressive early CABG procedures have more extensive disease, are more seriously ill, and are less able to tolerate further procedures.

Effect of Gender on Time to Failure

We next examined whether gender influenced time to failure of initial CABG procedures. Looking at the 144 men and 105 women in our sample who received initial CABG and subsequent PTCA, we found that women "failed" their initial CABG procedures at a faster rate than did men, with differences becoming apparent by one year and increasing over time. Both the Wilcoxon and log-rank statistics were significant at .005. Although we did not perform survival analysis while simultaneously controlling for gender and the number of vessels performed during the first CABG procedure, it is likely that an association between these two variables explains the higher failure rates for post-CABG women undergoing subsequent PTCA. Women have fewer grafts inserted during CABG procedures. As an indicator of severity of illness, number of grafts during initial CABG may influence the need for (or ability to undergo) further procedures for coronary artery disease. On the other hand, when comparing the 92 men and 46 women who underwent initial and subsequent CABGs, we found no significant difference in time to second procedure.

We then examined gender differences for patients with initial PTCA and subsequent PTCA or CABG.. There were 843 men and 514 women who had initial and subsequent PTCAs. Men underwent subsequent PTCAs somewhat earlier than did women, but the difference in survival curves for the initial PTCA was of borderline significance. Differences between post-PTCA men (418) and women (210) were more marked when the second procedure was a CABG. Men had significantly higher failure rates than women, with survival curves clearly diverging by 150 days. Wilcoxon and log-rank tests were significant at the 0.005 level.

Effect of Age on Time to Failure

Finally, we examined the influence of age on time to second procedure. We placed beneficiaries into three age groups, based on age at the time of the first procedure: under 65, 65 to 74, and 75 or older. For patients with initial PTCAs who later received CABGs, patients

under 65 years appeared to have significantly longer intervals between PTCA and CABG than did older patients. Both the Wilcoxon and log-rank tests were significant at the .05 level. For the other three paths (CABG to CABG, CABG to PTCA, and PTCA to PTCA) age at initial procedure appeared to have no significant effect on time to second procedure.

3.2 Computerized Axial Tomography (CT) and Magnetic Resonance Imaging (MRI) Scans of the Head

3.2.1 Utilization of CT and MRI Scans of the Head

Computerized axial tomography (CT) scanning has been available clinically since 1973. Its clinical advantages (detailed cross-sectional anatomical views) were so clear that it quickly diffused, despite DON hurdles. By the mid-1980s, CT scans had become a standard diagnostic procedure, especially for head and brain pathology. The high incidence of head and brain disorders in the elderly (because of strokes, neoplasms, and trauma) have made head CT scans a high-volume procedure in the Medicare population. Between 1.5 and 2 million head CTs are performed annually under Medicare, with an increase of 24.9 percent between 1986 and 1989 (Table 3-11). This increase in volume was almost entirely due to an increase in the number of beneficiaries receiving scans; users per eligible increased 14.5 percent. The number of head CTs per user increased only slightly over the four-year period, from 1.24 to 1.30 per user per year.

Theoretically, there are three ways a physician can bill a CT scan: technical component only (the process of obtaining the multiple cross-sectional X-ray images), professional component only (the interpretation of the sequence of cross-sectional images), or the complete procedure. Practically, physicians either perform and bill the complete procedure (obtain the scan and interpret it), or simply bill the professional component (interpretation of a scan performed using a hospital-owned CT scanner). Typically, physicians are reimbursed three times as much for the complete procedure as for interpretation only.

Mean allowed charges for complete and professional levels of service are shown in Table 3-12 for all procedure codes for head CTs. Between 1985 and 1988, mean reimbursement for complete procedures (all codes) increased steadily, from $274 to $327, while reimbursement for interpretation increased from $87 to $101. In 1989, however, mean Medicare reimbursement fell for both complete CT scans and interpretations. This reversal in price trends is probably a result of the Medicare fee schedule for radiology services, which took effect in April 1989.

Most head CT scans are examinations of the complete head (codes 70450 through 70470) rather than of specific structures such as the orbit, brainstem, or ear (70480 through 70482); see Table 3-13. In 1985 only 40 percent of complete head scans were being done without contrast (code 70450), while another 41 percent (code 70470) involved two scanning sequences: the first without and the second with contrast material. By 1988 the percent of single-sequence scans without contrast (70450) had increased to 50 percent. One explanation for this change may be that most head CTs (59%) are performed in inpatient settings (Table 3-14). Under prospective payment there is a clear incentive for hospitals to provide a less resource-intensive level of CT scanning, for example, by shifting to single-sequence scans without contrast.

In 1989, however, the trend toward less complex CT code was reversed. The percent of scans performed without contrast decreased from 50 to 44 percent. This change in the CT procedure code mix may possibly reflect a change in physician behavior related to the Medicare radiology fee schedule. Physicians who experienced a decrease in reimbursement per unit of service as a result of the fee schedule may have shifted to a more complex mix of services.

Although MRI scanning was introduced clinically in 1980, it is not until 1986 that we see substantial use of this diagnostic procedure among the Medicare population (Table 3-15). Between 1986 and 1989, the number of head MRI scans billed to Medicare increased by over 400 percent. This was almost entirely an increase in the number of users per year, since the number of procedures per user per year remained at or near one throughout the study period. Despite the rapid increase in MRI use, the 1989 utilization rate was only one-eighth that of

CT scans (9.22 versus 69.38 per 1,000 beneficiaries). The lower rate of MRI scans undoubtedly reflects its limited availability in some parts of the country, but may also be due to less familiarity among physicians regarding the indications for and advantages of MRI compared with CT.

Beginning in 1986, MRI procedure codes distinguished between scans of the orbit, face, and neck (code 70540) and scans of the brain, including brainstem (code 70551). More than 96 percent of head MRIs performed from 1986 to 1989 were scans of the brain and brainstem.

As with CT scans, physicians typically bill for either a complete MRI or for the professional component (interpretation) only. Physicians typically are reimbursed four times as much for the complete MRI procedure as for interpretation only (compared to a 3:1 ratio for complete CT versus interpretation). Mean allowed charges for these two levels of service are shown in Table 3-16 by procedure code and year of service. As with CT scans, mean reimbursement for complete MRI scans and interpretations decreased sharply in 1989, again perhaps reflecting implementation of a Medicare radiology fee schedule.

Perhaps because of changing hospital reimbursement rules and DON programs (which largely exclude physicians' offices), a much higher proportion of MRI scanners are located outside of hospitals (Hillman and Schwartz, 1985). According to the location codes used on physician claims, in 1985 and 1986 more than half of head MRIs were performed in physicians' offices; by 1988 this had decreased to 41 percent (Table 3-17). The remainder were evenly split between hospital inpatient and outpatient settings.

These data are misleading, however, since they rely on the service location recorded on the claim. Since so many MRI facilities are physician-owned, we were concerned that some Medicare inpatients might have MRIs performed in physician-owned facilities with the submitted bills showing a physician's office as the location of service. This in fact is the case. We identified all CT and MRI scans that were performed during an inpatient stay. (That is, the date of service of the scan fell between the admission and discharge dates of the hospital admission.) We then did a frequency of location of service as coded on the

physician claims for these scans, and found that only 73.0 percent of MRI head scans performed during hospital stays were coded as "inpatient hospital" on the physician's claim. The remainder were coded as "office" (17.0 %) or "outpatient hospital" (9.2 %). When we examined these data by carrier, we found that several carriers showed more than half of such hospital-stay MRI head scans billed with physician's office as the location of service. These changes in location of service coding have implications for Part B spending. As with other hospital services, the technical component of an MRI scan performed during a hospital admission would ordinarily be included in the hospital's DRG payment, and only the interpretation would be covered by Part B. If the MRI scan is billed as an office procedure, it is possible that both the technical and professional components of the scan are reimbursed by Part B.

Location of service coding for head CT scans, on the other hand, appears to be far more accurate. Overall, 88.3 percent of CT scans performed during hospital stays were billed as inpatient, with 9.6 percent billed as outpatient, and only 1.9 percent billed as office procedures.

3.2.2 Specialties of Physicians Performing CT and MRI Scans

Seventy percent of physicians billing complete CT scans and 80 percent of physicians billing complete MRIs were radiologists. However, 90 percent of physicians billing for CT or MRI interpretation were radiologists. Bills for interpretation only are usually submitted when the scan is performed in a hospital setting (inpatient or outpatient). In such cases, the hospital bills for the technical component through Medicare Part A, and the interpreting physician bills through Part B. Physicians interpreting scans in hospital settings are more likely to be radiologists. When a complete scan is billed, the scanner is most likely in a physician's office or in another physician-owned setting; in such settings, a somewhat greater number of scans are performed and interpreted by neurologists and physicians in multi-specialty group practice.

3.2.3 Sociodemographic Characteristics of Medicare Beneficiaries Receiving Head CT and MRI Scans

The mean age of beneficiaries receiving head CT scans was 74 to 75 during this study. After adjusting for age differences, males had a slightly higher utilization rate than did females (Table 3-18). Blacks had a higher utilization rate than did whites, after adjusting for age and sex.

The mean age of beneficiaries receiving head MRI scans increased somewhat over the five-year period. After adjusting for age differences, men have a higher utilization rate than do women (Table 3-19). Contrary to the pattern for CTs, however, the MRI utilization rate for whites is about 1.2 times higher than that for blacks.

The difference in black utilization rates for CT and MRI scans is interesting. Cerebrovascular disease accounts for more than a third of inpatient CT and MRI scans (see Section 3.2.6 below). Kittner (1990) recently showed that blacks have a higher incidence of strokes than do whites. This may partially explain the higher rate of CT use among black Medicare beneficiaries. However, the lower rate of MRI scans among blacks suggests the possibility that blacks have less access to this newer technology than do whites, even after controlling for primary insurance coverage (since all beneficiaries in our study are enrolled in Medicare Part B).

3.2.4 Repeat Use of CT and/or MRI Scans Within an Episode of Illness

CABG and PTCA procedures are used in the treatment of coronary artery disease, a chronic illness without easily defined episodes. However, CT and MRI are diagnostic procedures that may be used for many different types of medical problems. Head CTs and MRIs, for example, are used to diagnose strokes, to look for evidence of serious trauma after a fall, and to look for primary or secondary neoplasms in the brain. In order to analyze how CT and MRI scanning are combined or substituted within an episode of illness, we needed to define an episode of illness based on claims data. We first measured the interval in days

between scans for four different pathways: CT followed by CT; CT followed by MRI; MRI-CT; and MRI-MRI. For each pathway, we then plotted the frequency of occurrences over the interval in days, that is, the number of repeat CT scans with a one-day interval, etc. We found a clear break point in the frequency distribution at 30 days or lower for all four pathways. It thus appeared that 30 days approximated an "episode" in which repeat scans were likely to be performed.

We then constructed episodes of illness in the following manner. We divided beneficiaries into two groups: those whose first claim in our study period was a head CT, and those whose first claim was a head MRI. We examined each patient's claims for a 30-day period following the date of the first scan. If no repeat scans were performed during this period, the patient was considered to have had a 30-day episode of illness with only a single scan (which marked the beginning of the episode). If a second scan was encountered, the episode was extended to 30 days following the second scan. We counted the number of CT and MRI scans performed during these episodes, and measured the intervals between scans and the total duration of the episode of illness.

Data for patients with head CT scans as the first claim are shown in Table 3-20. The proportion of beneficiaries with repeat scans during an episode of illness increased from 11.7 to 13.0 percent over the five years, although the mean duration of an episode of illness fell slightly from 39.4 to 37.8 days. For those with repeat scans during an episode, the mean number of repeat scans (CT or MRI) was 1.3 for all five years. However, the mean number of repeat CT scans per episode decreased from 1.3 to 1.0, while the number of MRIs per episode for these patients increased from 0 to 0.3, exactly offsetting the decrease in CT scans. The mean interval between initial and repeat CT scans decreased from 7.3 to 5.8 days, while the mean interval between initial CT and subsequent MRI scan decreased from 9.3 to 5.5 days. These decreases may be related to increased efficiency on the part of providers in obtaining scans, to increased availability of scanning equipment, or to other factors. Although we did not examine the change in intervals between scans for inpatients separately, it is possible that decreases were greater for this group given hospital incentives for greater efficiency under prospective payment.

The second half of Table 3-20 shows data for beneficiaries who had an MRI as the first recorded head scan in our study period. These beneficiaries had slightly fewer repeat scans during an episode of illness (1.0 versus 1.3 for those with CT as first scan). While it is conceivable that MRI offered a diagnostic advantage over CT in these cases and fewer scans were thus needed, the more likely explanation is that patients receiving head MRI scans as a first procedure were simply less seriously ill. (More than 40 percent of head MRIs are performed in physicians' offices, compared to less than 10 percent of head CTs.) Beneficiaries with MRI as a first procedure were more likely to have a CT scan than an MRI as a repeat procedure.

3.2.5 Diagnoses of Beneficiaries Receiving CT and MRI Scans

We also looked at the diagnoses of patients who were hospitalized at the time a CT or MRI scan was performed, or who were admitted to an acute care hospital within 30 days of a CT or MRI scan. For this analysis, we used a linked HISKEW-MEDPAR-BMAD file. We thus had all diagnostic information contained on hospital claims. We formed 14 groups of ICD-9 diagnostic codes representing conditions in which head CT or MRI scanning is likely to be used. Table 3-21 shows the distribution of primary diagnoses across these 14 groups for all admissions in which CT and MRI head scans were performed in 1988. (Data are presented for 1989 only, since differences between years were minor.) Our 14 diagnostic groups accounted for two-thirds of all admissions in which head scanning was used. Neoplasms (including primary intracranial tumors and metastases) and cerebrovascular disease account for about 40 percent of the inpatient use of head scans. There is little apparent difference in the primary diagnoses of patients who received CTs and MRIs, although a higher proportion of MRI scans are done for neoplasms.

Again using our linked HISKEW-MEDPAR-BMAD file, we examined primary diagnoses for patients who were hospitalized within 30 days following a head CT or MRI scan (Table 3-22). The distribution of diagnoses was similar to those associated with inpatient scans, except that a higher proportion of the ambulatory CT and MRI scans appear to be cancer-related.

3.3 Extracorporeal Shock Wave Lithotripsy (ESWL) and Other Methods of Extracting Kidney Stones

3.3.1 Utilization of ESWL and Other Stone Extraction Methods

Rapid changes are occurring in the application of technology to the treatment of urinary tract stones. Between 1986 and 1989, the number of ESWL procedures under Medicare grew by 111 percent (Table 3-23). This appears to be largely due to the diffusion of this technology over time; user rates doubled, with little change in intensity.

At the same time, dramatic changes were taking place in the use of surgical approaches to stone disease. Open surgical techniques (including nephrolithotomy, pyelotomy, and ureterolithotomy) accounted for 27.5 percent of surgical procedures in 1985 (8,608/31,300), but only 6.5 percent (2,980/45,880) in 1989 (Table 3-24). The remainder (93.5 percent in 1989) were percutaneous or transurethral endoscopic procedures, which have much lower morbidity than open surgical approaches. The most marked increases were in the use of cystourethroscopy (codes 52310 to 52337). While the total use rate (procedures per eligibles) grew 35.7 percent, this reflected a net gain from a 56.0 percent growth in endoscopic procedures offsetting the 52.4 percent reduction in open surgical procedures.

Between 1985 and 1989, there was also a marked shift in the location of both lithotripsy and surgical stone extraction procedures. By 1989, less than one-half of ESWL procedures (46%) were performed in inpatient settings (see Table 3-25). The proportion of endoscopic procedures performed in inpatient settings had decreased from 83 to 55 percent. While nearly all open procedures for stone removal were still performed in inpatient settings, the absolute volume of these procedures had shrunk by two-thirds between 1985 and 1989 (recall Table 3-24).

Thus, several processes were occurring simultaneously during our study period: extracorporeal lithotripsy was diffusing rapidly; urologists were shifting from open to

endoscopic surgical treatment of stones; the total number of procedural interventions in stone disease was increasing (including lithotripsy, endoscopy, and open surgical procedures); and the location of intervention was shifting significantly to ambulatory settings. These changes are clearly not independent. Endoscopic procedures were substituting for open procedures, but were also being used jointly with ESWL in a number of cases. Combined use of stone technologies within an episode of illness is discussed in Section 3.3.4 below.

Mean allowed Part B charges for ESWL and for other methods of extracting stones are shown in Table 3-26. The mean reimbursement for ESWL grew by 8.9 percent between 1986 and 1989. Mean allowed charges for endoscopic procedures increased by 7.5 percent, while those for open surgical methods increased by 10.5 percent.

3.3.2 Specialties of Physicians Performing ESWL and Other Stone Extraction Procedures

Urologists billed 92.8 percent of ESWL claims. Another 5.2 percent were billed by clinics or other group practices. Overall, 78.9 percent of the surgical stone procedures were performed by urologists, with another 14.9 percent done by radiologists (primarily cystourethroscopy). Another 3.5 percent are billed by group practices, with only 2.7 percent by general surgeons and other physicians.

3.3.3 Sociodemographic Characteristics of Medicare Beneficiaries Receiving ESWL and Other Stone Extraction Methods

Only 29 claims for ESWL are in our sample for 1985, and sociodemographic characteristics of 1985 users are not representative of later years. Between 1986 and 1989, the mean age of ESWL users increased from 68.4 to 70.3 years. Age-adjusted utilization rates for males are about twice those for females, while age- and sex-adjusted rates for whites were about 1.8 those for blacks (Table 3-27). These sex and race differences are stable between 1986 and 1989.

The mean age of users ranged from 70 to 72 years over the study period for both endoscopic and open surgical procedures. For both procedure groups, utilization rates for males exceeded those for females by at least 2:1 in all years; utilization rates were also higher for whites than for blacks (Tables 3-28 and 3-29).

3.3.4 Combined Use of ESWL and Other Methods of Stone Extraction Within an Episode of Illness

As with the other two pairs of technology, we wanted to determine ways in which lithotripsy and other treatments for stone disease substitute for one another or are used jointly or sequentially in the same patient. Review of the literature showed that lithotripsy and endoscopic methods are often used in the same episode of stone disease. We wanted to analyze the patterns of use of these technologies in greater detail for the Medicare population.

Patients who have single episode of urinary stone disease have a recurrence rate of 15 to 50 percent over the next 12 months, and a declining risk of recurrence thereafter. Five-year recurrence rates have been reported as between 20 and 50 percent (Schuster and Schaeffer, 1984; Mulley, 1988). Unlike coronary artery disease, however, stone disease can be thought of as episodic rather than progressive. We therefore chose to examine the use of stone treatment technologies within discrete episodes of illness. A preliminary analysis of our data showed that most repeat stone procedures occurred within 60 days of the first. We therefore defined an "episode" of stone disease to extend 60 days from the first intervention (ESWL, open surgery, or endoscopy).

Using this definition, we performed a cross-tabulation for beneficiaries who had repeat procedures within 60 days. We chose to analyze data for only 1989, since patterns of use of these three treatments were evolving rapidly over the five-year study period.

In 1989, almost one-third (30.9%) of beneficiaries undergoing procedures for urinary stones received at least two procedures within a 60-day episode of illness. Patients with ESWL as a first procedure were most likely to undergo a second procedure within 60 days:

40.7 percent received repeat procedures, versus 21.1 percent of those with endoscopy. No patients with open surgery had repeat procedures of any type (ESWL, endoscopy, or open surgery) within a 60-day episode of illness; however, the number of beneficiaries in our sample undergoing open surgery in 1989 was very small.

As shown in Table 3-30, the most frequent combination of treatments was ESWL and endoscopy. One-half of the 1989 beneficiaries with repeat procedures received a combination of ESWL and endoscopy (38.8% + 15.6% = 54.4%); in two-thirds of these cases lithotripsy preceded endoscopy. Another 34.9 percent of repeat users had two endoscopic procedures. Most of these are cases in which cystourethroscopy was repeated. Only 10.6 percent of repeat users received two separate ESWL treatments.

TABLE 3-1

GROWTH IN THE USE OF CORONARY ARTERY BYPASS GRAFT SURGERY OVER TIME

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
TOTAL PROCEDURES[a]	71,460	84,640	98,460	103,480	116,500	37.6%
Rates (per 1,000 eligibles)						
Number of Operations	2.49	2.93	3.37	3.49	3.87	32.1
Number of Unique Patients	2.40	2.80	3.20	3.30	3.85	37.5
Procedures Per User	1.04	1.05	1.05	1.06	1.01	-3.8

[a] Sample numbers have been multiplied by 20 to obtain national estimates.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-2

DISTRIBUTION OF CORONARY ARTERY BYPASS GRAFTS BY PROCEDURE CODE AND YEAR[a]

		1985	1986	1987	1988	1989
33510	Single autogenous graft	6.8%	6.5%	6.1%	5.8%	6.4%
33511	Two grafts	17.1	17.0	15.9	16.9	16.8
33512	Three grafts	33.1	34.5	33.7	34.3	33.9
33513	Four grafts	27.1	27.4	28.7	28.0	29.0
33514	Five grafts	11.0	11.1	12.2	11.9	11.0
33516	Six or more grafts	4.0	3.3	3.2	3.1	2.8
33520 - 33528	Nonautogenous grafts	0.8	0.1	0.1	0.1	0.1

[a] Columns sum to 100%.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-3

TRENDS IN AVERAGE ALLOWED CHARGES FOR CABG SURGERY

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
33510 - Single Graft	$2,512	$2,573	$2,756	$2,730	$2,685	4.4%
33511 - Two Grafts	3,356	3,453	3,688	3,622	3,660	6.0
33512 - Three Grafts	3,744	3,849	4,130	4,074	4,094	6.4
33513 - Four Grafts	3,986	4,065	4,340	4,290	4,312	6.1
33514 - Five Grafts	4,160	4,297	4,466	4,441	4,466	3.9
33516 - Six or More Grafts	4,131	4,220	4,721	4,607	4,684	11.0
Weighted Average	3,691	3,819	4,094	4,040	4,052	6.1

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-4

GROWTH IN THE USE OF PERCUTANEOUS TRANSLUMINAL CORONARY ANGIOPLASTY OVER TIME

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
TOTAL PROCEDURES[a]	21,140	31,260	55,000	65,920	85,840	74.6%
Rates (per 1,000 eligibles)						
Number of Procedures	0.74	1.08	1.88	2.22	2.85	163.9
Number of Unique Patients	0.62	0.91	1.54	1.76	2.30	152.7
Procedures Per User	1.18	1.18	1.22	1.26	1.24	5.1

[a] Sample numbers have been multiplied by 20 to obtain national estimates.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-5

TRENDS IN AVERAGE ALLOWED CHARGES FOR PTCA

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
92982 - Single Vessel	$1,297	$1,340	$1,436	$1,507	$1,496	11.6%
92984 - Each Additional Vessel[a]	135	638	487	482	566	11.3
93570 - Single Vessel[b]	1,160	--	--	--	--	--
Average Per Claim	1,256	1,312	1,361	1,406	1,417	8.0
Average Per Treatment	1,257	1,367	1,475	1,555	1,548	13.2

[a] This code was first used in the 1986 edition of CPT-4.

[b] This code was deleted after the 1985 edition of CPT-4.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-6

TRENDS IN CABG UTILIZATION BY PATIENT CHARACTERISTICS (per 1,000 eligibles)[a]

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
ALL ELIGIBLES	2.49	2.93	3.37	3.49	3.87	32.1%††
Sex[a]						
Male	3.95	4.62	5.31	5.58	6.39	38.3††
Female	1.34	1.63	1.93	2.01	2.28	39.9††
	**	**	**	**	**	
Race[b]						
White	2.69	3.17	3.65	3.90	4.29	35.3††
Black	0.68	0.93	1.22	1.21	1.58	69.9††
	**	**	**	**	**	
Age[c]						
< 65 years	2.63	2.73	2.71	2.29	2.68	-1.8^{ns}
65-74 years	3.34	3.84	4.41	4.54	4.90	27.6††
75-84 years	1.53	2.13	2.64	3.01	3.33	56.3††
85+ years	0.18	0.21	0.31	0.40	0.44	109.5††
	**	**	**	**	**	
Location[b]						
Urban	2.54	2.97	3.41	3.49	3.83	29.0††
Rural	2.34	2.79	3.24	3.46	3.72	33.3††
	*	ns	ns	ns	ns	
Region[b]						
Northeast	1.92	2.41	2.75	2.83	3.46	43.6††
North Central	2.31	2.72	3.41	3.71	4.14	52.2††
South	2.58	3.17	3.54	3.84	4.22	33.1††
West	3.05	3.22	3.83	3.98	3.95	22.7††
	**	**	**	**	**	

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[a] Rates are adjusted for age.

[b] Rates are adjusted for age and sex.

[c] Rates are adjusted for sex.

[ns] χ^2 for differences in unadjusted utilization rates is not significant.

* χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .05.

** χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .01.

[††] χ^2 for changes in unadjusted utilization rates between 1986 and 1989 is significant at p = .01.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-7

TRENDS IN PTCA UTILIZATION BY PATIENT CHARACTERISTICS (per 1,000 eligibles)[a]

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
ALL ELIGIBLES	0.74	1.08	1.88	2.22	2.85	163.9%[††]
Sex[a]						
Male	1.04	1.53	2.66	3.05	4.18	173.2[††]
Female	0.49	0.74	1.29	1.63	1.13	177.0[††]
	**	**	**	**	**	
Race[b]						
White	0.79	1.10	2.04	2.46	3.16	187.3[††]
Black	0.20	0.40	0.65	0.76	1.13	182.5[††]
	**	**	**	**	**	
Age[c]						
< 65 years	0.75	1.08	1.62	1.48	1.90	75.9[††]
65-74 years	1.01	1.41	2.45	2.89	3.59	154.6[††]
75-84 years	0.41	0.76	1.39	1.90	2.43	219.7[††]
85+ years	0.05	0.14	0.37	0.33	0.60	328.6[††]
	**	**	**	**	**	
Location[b]						
Urban	0.75	1.09	1.91	2.18	2.78	155.0[††]
Rural	0.70	1.05	1.80	2.34	2.84	170.5[††]
	ns	ns	ns	ns	ns	
Region[b]						
Northeast	0.43	0.79	1.14	1.18	1.56	97.5[††]
North Central	0.80	1.14	1.86	2.55	3.29	188.6[††]
South	0.64	1.00	2.06	2.46	3.02	202.0[††]
West	1.13	1.54	2.59	3.09	4.15	169.5[††]
	**	**	**	**	**	

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[a] Rates are adjusted for age.

[b] Rates are adjusted for age and sex.

[c] Rates are adjusted for sex.

[ns] χ^2 for differences in unadjusted utilization rates is not significant.

** χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .01.

[††] χ^2 for changes in unadjusted utilization rates between 1986 and 1989 is significant at p = .01.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-8

OVERALL FAILURE RATES AND TYPE OF SECOND PROCEDURE, BY TYPE OF FIRST PROCEDURE

	MEAN FOLLOW-UP TIME	OVERALL FAILURE RATE	TYPE OF SECOND PROCEDURE FOR OVERALL FAILURES	
			CABG	PTCA
CABG	2.0 Years	2.1%	45.1%	54.9%
PTCA	1.3 Years	33.6	34.8	65.2

Source: BMAD Beneficiary files, 1985-1989.

TABLE 3-9

SHORT-TERM FAILURE RATES AND TYPE OF SECOND PROCEDURE, BY TYPE OF FIRST PROCEDURE

	MEAN FOLLOW-UP TIME	SHORT-TERM FAILURE RATE	TYPE OF SECOND PROCEDURE FOR SHORT-TERM FAILURES	
			CABG	PTCA
CABG	1.5 Days	0.5%	78.0%	22.0
PTCA	1.3 Days	16.6	37.6	62.4

TABLE 3-10

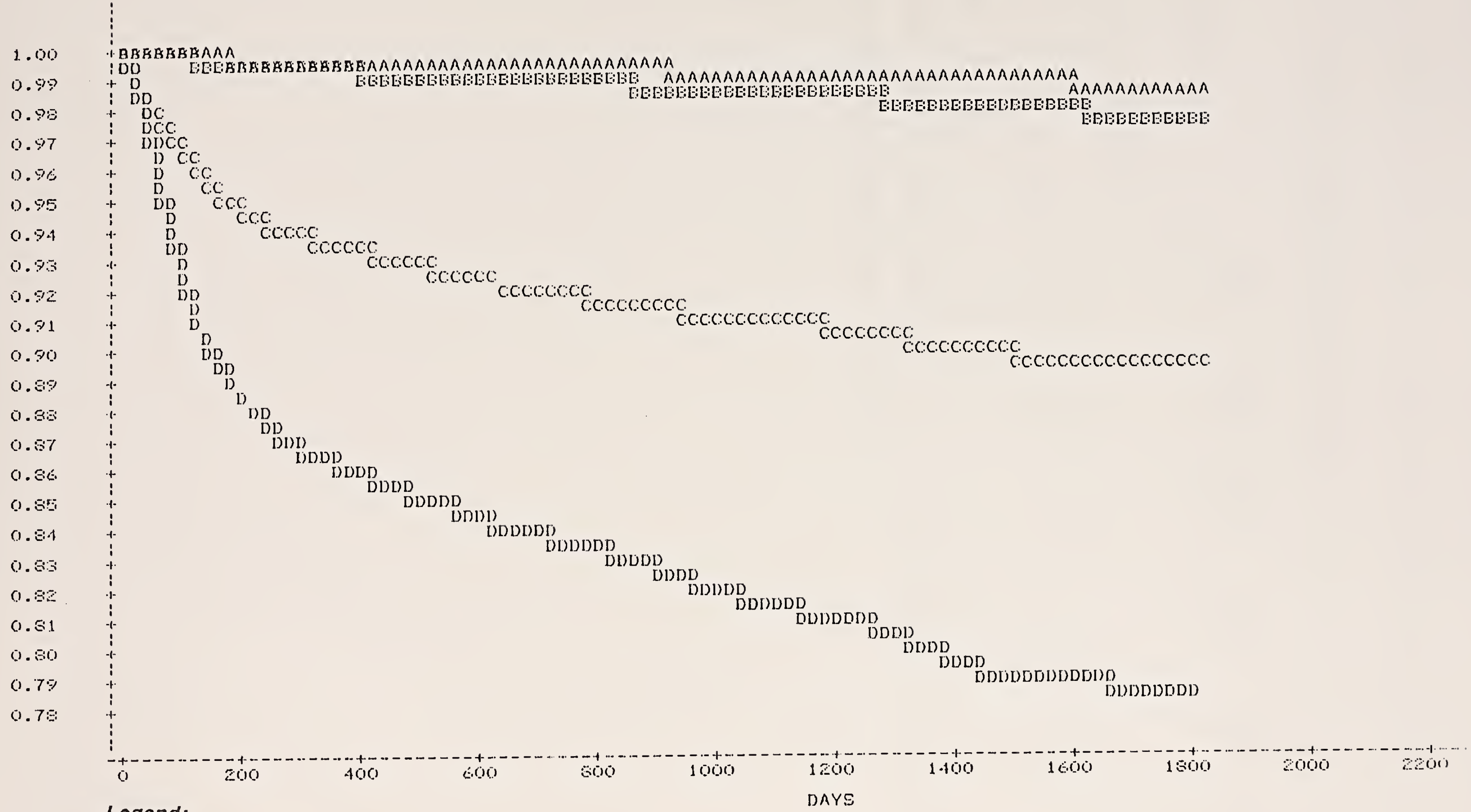
LONG-TERM FAILURE RATES AND TYPE OF SECOND PROCEDURE, BY TYPE OF FIRST PROCEDURE*

	MEAN FOLLOW-UP TIME	LONG-TERM FAILURE RATE	TYPE OF SECOND PROCEDURE FOR LONG-TERM FAILRURES	
			CABG	PTCA
CABG	2.0 Years	1.7%	35.7%	64.3%
PTCA	1.5 Years	20.3	31.6	68.4

*Excludes failures in first seven days.

FIGURE 3-1

TIME TO RETREATMENT BY PATH



Legend:

A - First procedure is CABG, second procedure is CABG.
B - First procedure is CABG, second procedure is PTCA.
C - First procedure is PTCA, second procedure is CABG.
D - First procedure is PTCA, second procedure is PTCA.

Source: BMAD Beneficiary File, 1985-1989.

TABLE 3-11

GROWTH IN THE USE OF HEAD CT SCANS OVER TIME

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
TOTAL PROCEDURES (in 000s)[a]	1,525.7	1,674.4	1,912.4	1,956.2	2,091.1	24.9%
Rates (per 1,000 eligibles)						
Number of Scans	53.26	57.98	65.41	65.97	69.38	19.6
Number of Unique Patients	42.55	46.56	51.30	51.20	53.31	14.5
Procedures Per User	1.25	1.24	1.28	1.29	1.30	4.8

[a] Sample numbers have been multiplied by 20 to obtain national estimates.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-12

TRENDS IN AVERAGE ALLOWED CHARGES FOR CT SCANS OF THE HEAD

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
70450 - CT, head without contrast	$231	$246	$265	$284	$268	8.9%
- interpretation only	76	82	90	93	72	-12.2
70460 - CT, head with contrast	270	285	305	321	319	11.9
- interpretation only	86	90	98	100	87	-3.3
70470 - CT, head w & w/out contrast	311	328	348	370	372	13.4
- interpretation only	99	104	112	114	98	-5.8
70480 - CT, orbit, without contrast	196	236	246	262	253	7.2
- interpretation only	80	85	87	87	90	5.9
70481 - CT, orbit, with contrast	255	272	294	308	304	11.8
- interpretation only	89	90	95	94	95	5.6
70482 - CT, orbit, w & w/out contrast	267	288	308	311	342	18.8
- interpretation only	104	105	111	102	103	-1.9
Weighted Average						
-Complete procedure	274	288	308	327	320	11.1
-Interpretation only	87	92	99	101	83	-9.8
-All	102	108	116	119	102	-5.6

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-13

SHIFTS IN PROCEDURE CODE MIX FOR HEAD CT SCANS[a]

PROCEDURE	1985	1986	1987	1988	1989
70450 - CT, head without contrast	39.9%	43.2%	46.1%	50.0%	44.3%
70460 - CT, with contrast	16.6	14.6	12.9	11.0	10.3
70470 - CT, without contrast, followed by contrast	40.9	39.4	37.8	35.9	41.1
70480 - CT, orbit, sella, or posterior fossa or outer, middle, or inner ear; without contrast	0.9	1.0	1.2	1.3	1.6
70481 - CT, with contrast	0.8	1.0	1.2	1.1	1.6
70482 - CT, without contrast, followed by contrast	0.9	0.8	0.8	0.7	1.1

[a] Columns sum to 100 percent.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-14

CHANGES IN LOCATION OF SERVICE FOR HEAD CT SCANS[a]

	1985	1986	1987	1988	1989
Office	8.5%	9.1%	9.0%	8.8%	9.0%
Inpatient	65.4	63.1	60.9	59.9	58.7
OPD	25.9	27.6	29.9	31.0	31.9
Other	0.2	0.2	0.2	0.3	0.4

[a] Columns sum to 100 percent.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-15

GROWTH IN THE USE OF HEAD MAGNETIC RESONANCE IMAGING (MRI) OVER TIME

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
TOTAL PROCEDURES[a]	1,440	58,920	133,960	204,820	302,980	414.2%
Rates (per 1,000 eligibles)						
Number of Scans	0.05	2.04	4.58	6.91	10.05	392.6
Number of Unique Patients	0.05	1.95	4.31	6.49	9.22	372.8
Procedures Per User	1.00	1.04	1.06	1.06	1.09	4.8

[a] Sample numbers have been multiplied by 20 to obtain national estimates.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-16

TRENDS IN AVERAGE ALLOWED CHARGES FOR MRI OF THE HEAD

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
70540[a] - MRI, orbit, face	--	$550	$650	$632	$597	8.5%
- interpretation only	$107	138	139	156	138	0.0
70550[b] - MRI, brain	510	--	--	--	--	--
- interpretation only	--	--	--	--	--	--
70551[a] - MRI, brain (inc. brain stem)	619	629	639	638	608	-3.3
- interpretation only	118	159	149	155	130	-18.2
70552[b] - MRI, brain stem	460	--	--	--	--	--
- interpretation only	--	--	--	--	--	--
Weighted Average						
-Complete procedure	571	626	639	638	607	-3.0
-Interpretation only	161	159	148	155	130	-18.2
-All	366	403	364	356	314	-22.1

[a] This code was first used in the 1986 edition of CPT-4.

[b] This code was used only in the 1985 edition of CPT-4.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-17

CHANGES IN LOCATION OF SERVICE FOR HEAD MRIs[a]

	1985	1986	1987	1988	1989
Office	52.1%	51.5%	46.1%	42.9%	41.2%
Inpatient	23.3	21.5	25.6	25.7	26.5
OPD	23.3	25.1	27.0	29.5	30.9
Other	1.4	2.0	1.3	1.8	1.4

[a] Columns sum to 100 percent.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-18

TRENDS IN HEAD CT UTILIZATION BY PATIENT CHARACTERISTICS (per 1,000 eligibles)[a]

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
ALL ELIGIBLES	53.26	57.98	65.41	65.97	69.38	19.7%[††]
Sex[a]						
Male	59.32	65.83	72.02	72.22	72.97	10.8[††]
Female	50.71	56.10	63.27	64.08	72.77	29.7[††]
	**	**	**	*	ns	
Race[b]						
White	53.68	59.61	66.22	67.32	72.52	21.7[††]
Black	62.59	70.92	79.68	83.60	92.30	30.1[††]
	**	**	**	**	**	
Age[c]						
< 65 years	36.98	40.47	43.33	39.73	44.67	10.4[††]
65-74 years	44.32	47.84	52.55	51.37	53.29	11.4[††]
75-84 years	70.14	79.26	88.06	90.80	94.87	19.7[††]
85+ years	73.52	83.36	99.28	107.43	114.95	37.9[††]
	**	**	**	**	**	
Location[b]						
Urban	56.75	62.26	68.47	68.85	72.29	16.1[††]
Rural	42.50	48.72	56.49	57.55	61.12	25.5[††]
	**	**	**	**	**	
Region[b]						
Northeast	54.65	63.05	69.85	67.11	72.29	14.7[††]
North Central	51.01	53.03	63.31	67.20	71.68	35.2[††]
South	52.88	61.21	68.82	74.19	79.55	30.0[††]
West	47.19	53.20	55.58	56.43	58.89	10.7[††]

[a] Rates are adjusted for age.

[b] Rates are adjusted for age and sex.

[c] Rates are adjusted for sex.

[ns] χ^2 for differences in unadjusted utilization rates is not significant.

[*] χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .05.

[**] χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .01.

[††] χ^2 for changes in unadjusted utilization rates between 1986 and 1989 is significant at p = .01.

Source: BMAD Beneficiary files, 1985-1989.

TABLE 3-19

TRENDS IN HEAD MRI UTILIZATION BY PATIENT CHARACTERISTICS (per 1,000 eligibles)[a]

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
ALL ELIGIBLES	0.05	2.04	4.58	6.91	10.05	392.6%
Sex[a]						
Male	0.06	2.12	4.82	7.26	10.80	409.4[††]
Female	0.04	1.99	4.46	6.77	10.22	413.6[††]
	ns	*	**	**	**	
Race[b]						
White	0.05	2.12	4.72	7.28	10.89	413.7[††]
Black	0.02	1.21	3.23	4.94	9.09	651.2[††]
	ns	**	**	**	**	
Age[c]						
< 65 years	0.06	2.47	4.76	5.88	9.06	266.8[††]
65-74 years	0.06	2.07	4.54	6.89	9.96	381.2[††]
75-84 years	0.05	2.16	5.19	8.17	11.71	442.1[††]
85+ years	0.03	0.76	2.45	4.15	6.47	751.3[††]
	ns	**	**	**	**	
Location[b]						
Urban	0.05	2.35	5.22	7.77	11.07	371.1[††]
Rural	0.04	1.17	2.84	4.50	7.25	519.7[††]
	ns	**	**	**	**	
Region[b]						
Northeast	0.03	1.59	4.02	5.85	8.87	457.9[††]
North Central	0.04	1.26	2.77	5.59	8.51	575.4[††]
South	0.04	1.92	4.53	7.31	11.34	490.6[††]
West	0.09	4.04	8.42	10.89	14.24	252.5[††]
	*	**	**	**	**	

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[a] Rates are adjusted for age.

[b] Rates are adjusted for age and sex.

[c] Rates are adjusted for sex.

[ns] χ^2 for differences in unadjusted utilization rates is not significant.

[*] χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .05.

[**] χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .01.

[††] χ^2 for changes in unadjusted utilization rates between 1986 and 1989 is significant at p = .01.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-20

REPEAT USE OF HEAD CT AND/OR MRI SCANS

WHEN CT IS FIRST PROCEDURE

	Percent with Repeat Scans	Mean Number of Repeat CT Scans*	Mean Number of MRI Scans*	Mean Total Repeat Scans*	Mean Days CT-CT	Mean Days CT-MRI	Mean Days Episode
1985	11.7%	1.3	0.0	1.3	7.3	9.3	39.4
1986	12.9	1.2	0.1	1.3	6.7	8.7	39.0
1987	14.6	1.2	0.1	1.3	6.4	7.7	38.8
1988	15.7	1.1	0.2	1.3	6.0	7.1	38.4
1989	13.0	1.0	0.3	1.3	5.8	5.5	37.8

WHEN MRI IS FIRST PROCEDURE

	Percent with Repeat Scans	Mean Number of Repeat MRI Scans*	Mean Number of CT Scans*	Mean Total Repeat Scans*	Mean Days MRI-MRI	Mean Days MRI-CT	Mean Days Episode
1985	8.8%	0.0	1.0	1.0	0.0	5.7	35.7
1986	7.3	0.3	0.7	1.0	3.9	6.8	38.0
1987	8.1	0.3	0.8	1.1	3.6	6.7	38.5
1988	8.3	0.3	0.7	1.0	3.2	5.6	37.3
1989	5.9	0.4	0.7	1.0	5.0	7.1	37.7

*Includes in denominator only those beneficiaries who had repeat scans within an episode of illness.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-21

PRIMARY DIAGNOSES OF PATIENTS WITH HEAD CT OR MRI SCANS DURING HOSPITAL ADMISSION FOR 1989

ICD-9	Description	Head CT	Head MRI
140 - 239	Neoplasms	7.2%	10.9%
240 - 278	Endocrine, Nutritional, Metabolic	4.5%	3.5%
290 - 294, 310	Organic Psychotic Conditions, Organic Brain Damage	2.7%	3.8%
295 - 299	Non-organic Psychosis	2.2%	4.3%
303 - 304	Alcohol or Drug Dependence	0.2%	0.3%
320 - 326	Inflammatory Conditions of the Nervous System	0.3%	0.3%
345	Epilepsy	1.5%	2.1%
426 - 427	Conduction Disorders, Cardiac Dysrythmias	2.4%	1.3%
428	Heart Failure	1.8%	1.1%
430 - 432	Intracranial Bleeding	5.2%	2.6%
433 - 434	Occlusion/Stenosis of Precerebral/Cerebral Arteries	16.6%	19.1%
435	TIA	6.9%	6.4%
436 - 438	Other Cerebrovascular Disease	7.0%	6.9%
780	General Symptoms (includes stupor, coma, syncope, collapse)	6.3%	5.7%
Total Percent of Admissions with Head CT or MRI Scans Included in These Diagnostic Groups		65.0%	68.3%
Estimated Number of Admissions with Inpatient Head CT or MRI Scans		1,190,220	94,120

Source: 1989 Linked MEDPAR and BMAD Beneficiary Files.

TABLE 3-22

PRIMARY DIAGNOSES OF PATIENTS ADMITTED WITHIN 30 DAYS FOLLOWING HEAD CT OR MRI SCAN IN 1989

ICD-9	Description	HEAD CT	HEAD MRI
140-239	Neoplasms	15.6%	25.0%
240-278	Endocrine, Nutritional, Metabolic	4.3%	3.3%
290-294, 310	Organic Psychotic Conditions, Organic Brain Damage	2.4%	1.7%
295-299	Non-Organic Psychosis	2.0%	2.4%
303-304	Alcohol or Drug Dependence	0.4%	0.2%
320-326	Inflammatory Conditions of the Nervous System	0.1%	0.2%
345	Epilepsy	0.9%	0.8%
426-427	Conduction Disorders, Cardiac Dysrythmias	2.7%	1.7%
428	Heart Failure	2.0%	1.2%
430-432	Intracranial Bleeding	2.2%	1.3%
433-434	Occlusion/Stenosis of Pre-cerebral/Cerebral Arteries	11.2%	7.7%
435	TIA	3.2%	2.7%
436-438	Other Cerebrovascular Disease	3.2%	2.3%
780	General Symptoms (includes stupor, coma, syncope, collapse	3.0%	2.5%
Total Percent of Admissions Included in These Diagnostic Groups		53.0%	53.1%
Estimated Number of Admissions within 30 Days of Ambulatory Head CT or MRI Scan		108,340	55,260

Source: 1989 Linked MEDPAR and BMAD Beneficiary Files.

TABLE 3-23

GROWTH IN THE USE OF EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY (ESWL) OVER TIME

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
TOTAL PROCEDURES[a]	580	9,420	15,560	15,740	19,840	110.6%
Rates (per 1,000 eligibles)						
Number of Procedures	0.02	0.33	0.53	0.53	0.66	100.0
Number of Unique Patients	0.02	0.29	0.48	0.48	0.58	100.0
Procedures Per User	1.04	1.14	1.11	1.10	1.13	-0.8

[a] Sample numbers have been multiplied by 20 to obtain national estimates.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-24

GROWTH IN THE USE OF SURGICAL METHODS FOR URINARY STONE EXTRACTION OVER TIME

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
Number of Procedures[a]						
Total	31,300	32,380	37,120	42,120	45,880	41.7%
Open Surgical Procedures	8,608	6,185	3,749	2,822	2,980	-51.8
Endoscopic Procedures	22,693	26,195	33,371	39,298	42,900	63.8
Rate of Operations (per 1,000 eligibles)						
Total	1.09	1.12	1.27	1.42	1.52	35.7
Open Surgical Procedures	0.30	0.21	0.13	0.10	0.10	-52.4
Endoscopic Procedures	0.79	0.91	1.14	1.33	1.42	56.0
Rate of Unique Patients (per 1,000 eligibles)						
Total	0.93	0.96	1.06	1.16	1.23	28.1
Open Surgical Procedures	0.28	0.20	0.12	0.09	0.08	-60.0
Endoscopic Procedures	0.69	0.77	0.92	1.01	1.15	49.4
Procedures Per User						
Total	1.18	1.17	1.20	1.23	1.24	6.0
Open Surgical Procedures	1.08	1.09	1.08	1.04	1.18	8.6
Endoscopic Procedures	1.15	1.18	1.24	1.31	1.24	4.8

[a] Sample numbers have been multiplied by 20 to obtain national estimates.

Source: BMAD Beneficiary files, 1985-1989.

TABLE 3-25

CHANGES IN LOCATION OF SERVICE FOR STONE PROCEDURES OVER TIME

	1985	1986	1987	1988	1989
ESWL[a]					
Office	4.7%	6.9%	11.5%	13.0%	6.4
Inpatient	95.3	80.0	61.6	54.4	46.0
OPD	0.0	12.9	25.8	31.4	45.9
Other	0.0	0.2	1.1	1.2	1.7
Open Surgical Procedures[a]					
Office	1.4%	3.0%	3.3%	2.9%	5.4
Inpatient	97.4	96.0	92.3	96.4	89.3
OPD	1.0	1.0	4.4	0.7	4.7
Other	0.2	0.0	0.0	0.0	0.6
Endoscopic Procedures[a]					
Office	7.4%	8.4%	15.0%	18.2%	20.4
Inpatient	83.3	79.6	67.2	61.8	55.0
OPD	8.9	11.9	16.9	19.0	24.0
Other	0.4	0.1	0.8	1.1	0.6

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[a] Columns sum to 100 percent.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-26

TRENDS IN AVERAGE ALLOWED CHARGES FOR ESWL VERSUS SURGICAL METHODS FOR REMOVING URINARY TRACT STONES

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
50590 - ESWL	$692	$915	$961	$964	$996	8.9%
SURGICAL METHODS[a]						
-Open Procedures	1,003	923	1,032	997	1,020	10.5
-Endoscopic Procedures	382	401	423	429	431	7.5
-All	556	505	486	467	469	-7.1

[a] Over a dozen CPT-4 codes are included in these categories. Weighted averages are shown here for ease of presentation. Similar data are available, however, on a CPT-4 code-specific basis.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-27

TRENDS IN ESWL UTILIZATION BY PATIENT CHARACTERISTICS (per 1,000 eligibles)[a]

	1985	1986	1987	1988	1989	1986–1989 PERCENT CHANGE
ALL ELIGIBLES	0.02	0.33	0.53	0.53	0.66	100.0%
Sex[a]						
Male	0.02	0.43	0.76	0.73	0.96	123.3[††]
Female	0.02	0.24	0.35	0.38	0.48	100.0[††]
	ns	**	**	**	**	
Race[b]						
White	0.02	0.34	0.56	0.55	0.72	111.8[††]
Black	0.01	0.22	0.28	0.40	0.39	77.3[†]
	ns	*	**	**	**	
Age[c]						
< 65 years	0.03	0.43	0.69	0.63	0.49	14.0[ns]
65–74 years	0.02	0.37	0.64	0.59	0.76	105.4[††]
75–84 years	0.02	0.26	0.39	0.49	0.58	123.1[††]
85+ years	0.00	0.10	0.11	0.13	0.26	160.0[††]
	ns	**	**	**	**	
Location[b]						
Urban	0.02	0.32	0.53	0.52	0.64	100.0[††]
Rural	0.02	0.33	0.53	0.55	0.68	106.1[††]
	ns	ns	ns	ns	ns	
Region[b]						
Northeast	0.00	0.17	0.36	0.40	0.49	188.2[††]
North Central	0.02	0.35	0.52	0.47	0.67	91.4[††]
South	0.04	0.41	0.69	0.73	0.88	114.6[††]
West	0.00	0.30	0.46	0.49	0.54	80.0[††]
	**	**	**	**	**	

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[a] Rates are adjusted for age.

[b] Rates are adjusted for age and sex.

[c] Rates are adjusted for sex.

[ns] χ^2 for differences in unadjusted utilization rates is not significant.

[*] χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .05.

[**] χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .01.

[†] χ^2 for changes in unadjusted utilization rates between 1986 and 1989 is significant at p = .05.

[††] χ^2 for changes in unadjusted utilization rates between 1986 and 1989 is significant at p = .01.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-28

TRENDS IN UTILIZATION OF OPEN SURGICAL PROCEDURES FOR STONE EXTRACTION BY PATIENT CHARACTERISTICS (per 1,000 eligibles)[a]

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
ALL ELIGIBLES	0.29	0.21	0.12	0.09	0.10	-52.4%[††]
Sex[a]						
Male	0.43	0.31	0.19	0.14	0.16	-48.4[††]
Female	0.18	0.14	0.08	0.06	0.06	-57.1[††]
	**	**	**	**	**	
Race[b]						
White	0.30	0.21	0.13	0.10	0.11	-47.6[††]
Black	0.19	0.14	0.10	0.08	0.05	-64.3[†]
	*	ns	ns	ns	ns	
Age[c]						
< 65 years	0.30	0.24	0.13	0.08	0.10	-58.3[††]
65-74 years	0.32	0.21	0.14	0.10	0.08	-61.9[††]
75-84 years	0.28	0.21	0.11	0.09	0.13	-38.1[††]
85+ years	0.10	0.10	0.05	0.08	0.07	-30.0[ns]
	**	*	ns	ns	ns	
Location[b]						
Urban	0.26	0.19	0.11	0.10	0.10	-47.4[††]
Rural	0.35	0.24	0.15	0.09	0.10	-58.3[††]
	**	*	ns	ns	ns	
Region[b]						
Northeast	0.30	0.22	0.14	0.09	0.10	-54.5[††]
North Central	0.20	0.17	0.09	0.08	0.08	-52.9[††]
South	0.35	0.23	0.13	0.10	0.12	-47.8[††]
West	0.24	0.16	0.11	0.10	0.10	-37.5[†]
	**	ns	ns	ns	ns	

---

[a] Rates are adjusted for age.

[b] Rates are adjusted for age and sex.

[c] Rates are adjusted for sex.

[ns] χ^2 for differences in unadjusted utilization rates is not significant.

[*] χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .05.

[**] χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .01.

[†] χ^2 for changes in unadjusted utilization rates between 1986 and 1989 is significant at p = .05.

[††] χ^2 for changes in unadjusted utilization rates between 1986 and 1989 is significant at p = .01.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-29

TRENDS IN UTILIZATION OF ENDOSCOPIC PROCEDURES FOR STONE EXTRACTION BY PATIENT CHARACTERISTICS (per 1,000 eligibles)[a]

	1985	1986	1987	1988	1989	1986-1989 PERCENT CHANGE
ALL ELIGIBLES	0.76	0.87	1.11	1.29	1.41	62.1%††
Sex[a]						
Male	1.25	1.44	1.87	2.08	2.24	55.6††
Female	0.41	0.48	0.61	0.81	0.93	93.8††
	**	**	**	**	**	
Race[b]						
White	0.79	0.92	1.19	1.40	1.55	68.5††
Black	0.50	0.61	0.68	1.00	0.97	59.0††
	**	**	**	**	**	
Age[c]						
< 65 years	0.84	0.83	1.02	1.11	1.31	57.8††
65-74 years	0.79	0.79	1.22	1.34	1.50	89.9††
75-84 years	0.69	0.68	1.07	1.39	1.40	105.9††
85+ years	0.69	0.68	0.70	0.94	1.51	122.1††
	ns	**	**	**	**	
Location[b]						
Urban	0.75	0.85	1.11	1.27	1.34	57.6††
Rural	0.80	0.93	1.10	1.36	1.57	68.8††
	ns	ns	ns	ns	**	
Region[b]						
Northeast	0.70	0.77	0.94	1.12	1.24	61.0††
North Central	0.70	0.80	1.13	1.37	1.49	86.3††
South	0.88	1.04	1.32	1.62	1.87	79.8††
West	0.57	0.70	0.83	0.97	0.93	32.9††
	**	**	**	**	**	

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[a] Rates are adjusted for age.

[b] Rates are adjusted for age and sex.

[c] Rates are adjusted for sex.

ns χ^2 for differences in unadjusted utilization rates is not significant.

** χ^2 for differences in unadjusted utilization rates for subgroups is significant at p = .01.

† χ^2 for changes in unadjusted utilization rates between 1986 and 1989 is significant at p = .05.

†† χ^2 for changes in unadjusted utilization rates between 1986 and 1989 is significant at p = .01.

Source: BMAD beneficiary files, 1985-1989.

TABLE 3-30

DISTRIBUTION OF USERS WITH REPEAT STONE PROCEDURES WITHIN A 60-DAY EPISODE OF ILLNESS (1989)

	Percent of All Users With Repeat Procedures	**Mean Interval Between Procedures (Days)**
ESWL Followed by Endoscopy	38.8%	20.0
Endoscopy Followed by ESWL	15.6	17.1
Endoscopy Followed by Endoscopy	34.9	20.1
ESWL Followed by ESWL	10.6	23.6
All Other Combinations	0.0	--
	100.0%	20.0

Source: BMAD Beneficiary File, 1989.

4.0 ANALYSIS OF TECHNOLOGY DIFFUSION ACROSS ELEVEN STATES

4.1 Introduction

The multi-state database, aggregated by area, provides a unique opportunity to study the geographic patterns of diffusion of the six technologies described above. As mentioned in Chapter One, our analysis of diffusion addresses several research questions. First, there is the task of disentangling increases in the volume of services from increases in intensity. To what extent are volume increases in high-technology services attributable to their spread to new areas, rather than a result of increased utilization within the same limited geographic areas? If volume increases can be explained by diffusion to new areas, we would expect some degree of variation in rates of increase across areas; utilization rates of areas that are initially very low use should increase more rapidly than areas where the procedure had already substantially diffused.

This brings about a further question: As technologies diffuse, how much variability is observed in levels of use? Are utilization rates of small areas and rural areas consistently lower than those of larger, more urbanized areas? Do these trends persist through time? If some areas are consistently showing lower than average utilization rates, questions may arise concerning equitable access to new technologies.

Geographic variation in use rates may, however, be an artifact of different observed stages of diffusion among areas. Do geographic areas with initially high utilization rates experience a levelling off while rates for areas with initially low utilization rates increase rapidly? If so, then geographic variation in utilization rates would be partially explained by an eventual convergence of rates.

The following sections seek to answer these questions. The first section decomposes trends in utilization rates by urban and rural areas, as well as by size of urban areas. The second section addresses the question of rate convergence. In particular, we classify areas based on their baseline utilization rates, and then track them over the study period.

4.2 Diffusion Trends Across Urban and Rural Areas

Tables 4-1 through 4-12 show trends in mean utilization rates for the paired procedures within urban (MSA) and rural areas (non-MSA), urban and rural areas by state, and for MSAs of varying population sizes; less than 125,000, 125-250,000, 250,000-500,000, 500,000 to 1 million, and over 1 million. The "over 1 million" urban group consists of the eleven largest cities, including Phoenix, Atlanta, Newark, and Philadelphia. All of the percent changes shown on these tables are calculated from 1986 to 1988. Trends from 1986 to 1988 are more meaningful because many areas had not adopted the new technologies (PTCA, MRI, and ESWL) by 1985. Total (urban and rural) trends are virtually identical to those shown earlier based on the national data. A separate table in Appendix B lists the individual MSAs included within each of the MSA size groups. Finally, it is important to note that statistical tests between means is not appropriate because we have the universe of claims from 11 states.

4.2.1 Diffusion of CABG and PTCA

Despite the fact that CABG surgery is a well-established Medicare procedure, its utilization rate climbed markedly (30.4%) between 1986 and 1988 (Table 4-1). While rates grew in both urban and rural areas, absolute levels remained slightly higher in MSAs. Rates for small urban areas (less than 125,000 people), are particularly noteworthy; they grew the least of all groups but had the highest utilization rates in each of the four years. This group included six MSAs (out of 10) with 1988 CABG rates greater than 4 per 1,000; these were Anniston, Dothan, and Gadsden (all in Alabama), Comanche and Enid (both in Oklahoma), and Olympia (Washington).

PTCA has diffused rapidly through urban as well as rural areas. Across all areas, rates of PTCA rose 106.3 percent from 1986 to 1988 (also seen in Table 4-1). PTCA use grew somewhat faster in urban areas than in rural areas. Rates of increase were steepest in the smallest MSAs, i.e., the same areas with particularly high CABG utilization as well.

CABG rates increased most rapidly (more than 40%) in Oklahoma, Oregon and Pennsylvania (see Table 4-2). In part, this reflects their below-average levels to start with; even so, by 1988, their utilization is still well below that of Alabama and Washington. Surprisingly, some of the most urbanized states (Connecticut, D.C., and New Jersey) exhibit both the lowest use levels and the slowest rates of growth.

Among our 11 states, PTCA appears to have adopted first, or at least to have diffused more quickly, in Kansas (Table 4-3). Utilization rates for this technology exceeded 2 per 1,000 in large MSAs like Kansas City and Topeka as early as 1985. Even rural residents of Kansas were undergoing PTCA at the rate of 1.35 per 1,000 by 1985. By 1988, urban areas of Kansas were performing PTCA at a higher rate than CABG surgery (3.86 versus 3.76).

4.2.2 Diffusion of CT and MRI

The rate of beneficiaries receiving CT scans increased somewhat slower than the rate for CABG over the time period (Table 4-4); 16.3 percent for all areas. Rates of CT scans increased most rapidly in rural areas; 23.6 percent compared to 14.6 percent for urban areas. The urban-rural differential closed considerably over the time period. In 1985, urban residents were 30 percent more likely to receive at least one CT scan than those in rural areas, compared with 15 percent in 1988. Large urban areas experienced the slowest growth during the time period, perhaps because CT scans would have been more diffused in these areas in 1985. Nevertheless, absolute levels remain highest in large urban areas, such as Atlanta, the District of Columbia, Milwaukee, and Philadelphia.

Like PTCA, MRI diffused rapidly over the study period (Table 4-4). From 1986 to 1988, the number of MRI users per thousand eligibles more than tripled from 2.2 to 6.9. Although rates of increase were faster for rural areas than for urban areas (281% versus 201%), absolute levels differed substantially across areas. In 1986, an urban resident was nearly twice as likely as a rural resident to receive at least one MRI scan. In 1988, that gap narrowed only slightly to 62 percent. Every year from 1986 to 1988, urban areas with

populations in the 250- 500,000 range (e.g., Mobile, Spokane, Trenton) had utilization rates substantially higher than MSAs in the other urban size categories. The early adopters of MRI, however, were mostly the largest cities such as Philadelphia, the District of Columbia, Kansas City, and Newark.

Urban-rural rate convergence for CT scanning is evident within states as well. States with high urban CT rates also had high rural CT rates, while states with lower than average urban rates also had lower rural rates (Table 4-5). For example, in Alabama and Pennsylvania, two states with above average levels of CT utilization, rural rates are similar to or exceed the 11-state urban average.

Among our 11 states, the most interesting utilization rate patterns for MRI are those of Alabama (see Table 4-6). In 1986, urban residents were more than three times more likely than rural residents to receive at least one MRI scan. Interestingly, this differential was not due to below-average rural rates; the 1986 11-state average was 1.3 per 1,000 while Alabama's rural average was 1.64 per 1,000. The rural rate grew faster than the urban rate from 1986 to 1988, however the urban rate remained the highest, in absolute terms, of all the states' urban areas.

Tables 4-7 and 4-8 differ from Tables 4-4 and 4-5 in that they report the total number of CT scans per eligible rather than the number of beneficiaries receiving scans (per eligible). For urban areas, the rate of CT scans per eligible appears to be leveling off between 1987 and 1988, while continuing to grow for rural residents. However, urban residents still receive 20 percent more scans per eligible than their rural counterparts (based on 1988 data). For MRI (Tables 4-7 and 4-9), the number of scans per eligible is very similar to the number of beneficiaries receiving scans (per eligible).

4.2.3 Diffusion of Stone Removal Procedures and ESWL

Rates for urinary tract stone removal procedures (other than ESWL), measured by a mix of both invasive and non-invasive surgical procedures, increased a total of 28.2 percent from 1986 to 1988 (Table 4-10). During the time period, the urban-rural differential never

rose above 14 percent, with rural residents (particularly those from Pennsylvania and Georgia) slightly more likely to undergo stone removal procedures. Combined with the relatively high absolute rate for small urban areas, this suggests that residents of less urbanized areas are more likely to need, or to seek care for, urinary tract stones. Urban and rural areas displayed similar rates of increase from 1986 to 1988: 27.7 and 33.6 percent, respectively.

Surprisingly, access to ESWL (as measured by levels of utilization) appears to be relatively equal across urban and rural areas as well as across MSAs of varying sizes (also on Table 4-10). As with stone removal procedures, the rural and small urban areas have higher absolute rates than other groups.

As mentioned earlier, geographic variation in stone removal procedures is believed to be due in part to the hardness of drinking water, with hard water areas, such as states in the Northwest (e.g., Oregon and Washington) having a lower incidence of stone disease than Southern states (e.g., Alabama and Georgia). Our analysis revealed similar findings; from 1986 to 1988, the Southern states in our sample consistently had the highest rates of surgical stone removal (Table 4-11).

Very limited use of ESWL was apparent first in Georgia in 1985, and by 1988, absolute rates were highest in it and our other Southern state: Alabama (Table 4-12). In 1988, for example, 0.77 out of 1,000 Alabama residents underwent ESWL (compared with zero in 1985), while 0.78 per 1,000 Georgia residents received this technology (up from 0.07 in 1985). This is in contrast with the rate of only 0.53 for all states in 1988.

4.3 Utilization Rate Convergence

4.3.1 Introduction and Methods

The diffusion of technologies and innovations are often modelled as following a predictable path. The literature points to the different stages of technology diffusion (Mansfield, 1968). Diffusion of new innovations begins slowly, typically following one or more

successful experiments by influential individuals. Then, as the technology becomes more accepted by professional and organizational groups, diffusion begins to increase more rapidly. After a period of rapid increase, the technology becomes standard and its rate of diffusion begins to slow. Diffusion theory has been applied, in varying ways, to the health care industry (see, for example, Cromwell and Pope, 1988; Sloan et al., 1986; McKinlay, 1981; and Greer, 1977).

The previous section showed that there can be substantial utilization rate variation among areas, which may be due in part to observing rates at different stages of diffusion. If this is true, based on the theory discussed above we would expect utilization rates for high, medium, and low use areas to, eventually, converge at some point in time (as the areas complete each stage of diffusion). A lack of convergence would indicate that there may be other factors explaining observed variation in utilization rates, especially for the three well-established procedures. In the case of the three new technologies, however, it may mean that our 1985-1988 time period is simply too short.

In order to measure convergence, high, medium and low use rate categories were defined for each procedure according to utilization rates in their baseline year (1986). Low-use areas are defined as having utilization rates in the lowest quartile in the baseline year, while high-use areas have rates falling into the top quartile in the baseline year. Average- use areas are those occupying the middle two quartiles in the baseline year. The baseline year is 1986 because of the large number of areas not experiencing any use of the newer procedures in 1985. Annual utilization rates were then tracked for each of the three groups of areas.

4.3.2 Results

The results of this analysis are shown in Table 4-13 and Figures 4-1 through 4-3. On Table 4-13, mean utilization rates (defined as the number of beneficiaries receiving the procedure divided by the number of Medicare eligibles) are shown for each rate category and for each of the four years. The number of areas grouped in each category is also shown. For

all procedures, rates of increase grew the fastest for initially low-use areas and the slowest for initially high-use areas, showing some general degree of convergence from 1986 to 1988. However, variation in absolute rates failed to decrease substantially over the time period. Figures 4-1 through 4-3 illustrate trends in utilization rates for the three technology pairs, providing a picture of the various stages of diffusion. For example, Figure 4-1 shows PTCA at the very beginning of the diffusion process, while CABG surgery is at a later stage. Similarly, graphs showing mean utilization rates for MRI and ESWL (Figures 4-2 and 4-3) illustrate the very beginning of the diffusion process. The established procedures, however, appear to be at later stages of diffusion throughout the time period.

Mean utilization rates of low-use CABG areas increased 43.8 percent from 1986 to 1988, while rates for high-use areas only grew 16.4 percent. The high-use/low-use differential narrowed from 110 percent in 1986 to 70 percent in 1988, providing evidence of a small degree of rate convergence over the time period. This trend is evident in Figure 4-1, which shows a slight tendency toward convergence throughout the time series. Included in the high use group were most Alabama MSAs as well as that state's rural counties, plus Phoenix, Topeka, Seattle, and various smaller MSAs. Areas with CABG utilization rates in the bottom quartile in 1986 included almost all of the large New Jersey MSAs and Portland (Oregon), as well as several smaller urban areas.

PTCA appears to be in its earlier stages of diffusion. With the exception of low-use areas, where use appears to have levelled off, rates continue to increase rather sharply (Figure 4-1). Differences in absolute levels remained high for all four years; the high-use/low-use differential decreased but remained relatively high (377 percent in 1986 to 77 percent in 1988). Most of the high PTCA use areas were in Kansas (including not only the large MSAs but also small urban areas like Lawrence and rural counties), and in Washington, ranging from Seattle to Longview. The remaining high use areas were Tucson and Atlanta.

Utilization rates for CT scans show only slight signs of convergence. Utilization rates of initially low-use areas are slowly catching those of initially high-use areas, although

substantial differentials persist throughout the time series (79 percent in 1986 and 68 percent in 1988). Figure 4-2 illustrates the continued differential between low-use and high-use areas.

Areas classified in the low CT utilization group were disproportionately rural, including rural areas from Arizona, Kansas, Oklahoma, Oregon, and Washington. High-use areas included many of the largest MSAs, such as Philadelphia and the District of Columbia, as well as a number of small MSAs from Alabama, Georgia, and Pennsylvania. Noteworthy exclusions from the high-use group were Phoenix, Newark, and all MSAs in Connecticut.

The four year time trend selected for our analysis captures MRI in its earliest stage of diffusion. Absolute rates for all three use categories increased rapidly over the time period, with mean utilization rates for low-use areas increasing 660 percent from 1986 to 1988. The high-use/low-use differential diminished somewhat in 1988, due mostly to a sharp increase in mean utilization rates for low-use areas rather than a slowing of rates for high-use areas. Figure 4-2 illustrates the rapid diffusion of MRI from 1985 to 1988, although it is clear that it is at a much earlier stage of diffusion than CT. Areas with low MRI use rates were disproportionately small MSAs. Surprisingly, all four large Connecticut MSAs had MRI utilization rates in the bottom quartile in 1986. Most of the large cities in our sample, however, with the exception of Seattle, Atlanta, and all Connecticut MSAs, were classified high-use MRI areas in 1986.

Mean utilization rates for surgical stone removal procedures showed limited convergence over the time period. Figure 4-3 shows that surgical stone removal procedures are in a later stage of diffusion, however mean utilization rates fail to show a trend toward convergence. A possible explanation of this could be that urinary tract stone removal shifted from more invasive procedures in the earlier years to less-invasive procedures in the later years. The less-invasive surgical procedures are relatively newly developed endoscopic techniques, which would be at an earlier stage of diffusion during the time period than the more invasive surgical techniques. It is possible that initially high-use areas for all surgical stone removal procedures are the first to begin using newer endoscopic techniques, which would explain the increase in the mean utilization rate of high-use areas.

Most of the areas showing higher than average use rates in 1986 were small urban and rural areas from Alabama, Georgia, Kansas, and Pennsylvania. Areas with low use rates in 1986 were primarily small MSAs and rural areas from non-Southern states (e.g., Arizona, Washington, and Oregon).

Unfortunately, the multistate analytic file used in this analysis was developed prior to the discovery (using the BMAD file) of the shift from more invasive methods to endoscopic methods. The data presented in Table 4-13 and Figure 4-3 illustrate two competing trends within the procedure defined as surgical stone removal, making it difficult to reach meaningful conclusions regarding convergence.

All three stages of diffusion mentioned above are illustrated by the trends in mean utilization rates for ESWL. Each rate category increased quickly in the earlier years and then began to level in the later years (Figure 4-3). Although it is not clear whether rates for each group will eventually converge, it is evident that rates for high and average-use areas begin to level between 1987 and 1988. Absolute differences in mean rates for high and low-use groups remained high throughout the time series; however, the gap narrowed considerably from 1986 to 1988 (3,250 percent in 1986 to 73 percent in 1988). Areas with low use rates in 1986 were mostly from a mix of non-Southern states.

Although ESWL and MRI are similar in that they are both costly to purchase (about $1 million for a lithotripter and $2-3 million for a magnetic resonance imager) and they are both technologically advanced devices, their differing patterns of diffusion may be due to their different applications in medicine. ESWL procedures are therapeutic and therefore the indications for their use are more established; while MRI is a diagnostic procedure and its indications are not as well defined.

TABLE 4-1

UTILIZATION OF CABG SURGERY AND PTCA OVER TIME (users per 1,000 eligibles)

	CORONARY ARTERY BYPASS GRAFT SURGERY				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	2.40	2.65	3.04	3.49	31.7%
All Urban	2.48	2.89	3.30	3.75	29.8
Size of MSA					
Less than 125,000	3.17	3.59	3.90	4.33	20.6
125,000 - 250,000	2.67	2.92	3.43	3.94	34.9
250,000 - 500,000	2.72	3.20	3.54	3.95	23.4
500,000 - 1 million	2.42	2.93	3.36	3.70	26.3
Over 1 million	2.39	2.74	3.17	3.67	33.9
All Areas	**2.46**	**2.83**	**3.24**	**3.69**	**30.4**

	PERCUTANEOUS TRANSLUMINAL CORONARY ANGIOPLASTY				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.64	1.09	1.71	2.21	102.8%
All Urban	0.72	1.11	1.67	2.32	109.0
Size of MSA					
Less than 125,000	0.48	0.80	1.68	2.37	196.3
125,000 - 250,000	0.61	0.97	1.44	2.17	123.7
250,000 - 500,000	0.97	1.45	2.05	2.33	60.7
500,000 - 1 million	0.52	0.88	1.63	2.26	156.8
Over 1 million	0.76	1.18	1.63	2.36	100.0
All Areas	**0.70**	**1.11**	**1.68**	**2.29**	**106.3**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-2

UTILIZATION OF CABG SURGERY BY STATE, OVER TIME (USERS PER 1,000 ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	3.96	4.13	4.52	4.60	11.4%
Urban	4.10	4.32	4.76	4.83	17.9
Rural	3.75	3.83	4.16	4.23	10.4
ARIZONA	3.08	2.64	3.04	3.22	22.0
Urban	3.34	2.79	3.33	3.46	24.0
Rural	2.11	2.12	2.03	2.42	14.2
CONNECTICUT	2.44	3.07	3.33	3.53	15.0
WASHINGTON D.C.	2.62	2.25	2.49	2.99	14.0
GEORGIA	2.43	2.68	2.96	3.32	23.9
Urban	2.88	3.03	3.36	3.79	25.1
Rural	1.89	2.25	2.47	2.73	21.3
KANSAS	2.71	2.96	3.15	3.62	22.3
Urban	2.96	3.21	3.30	3.76	17.1
Rural	2.41	2.65	2.97	3.46	30.6
NEW JERSEY	1.33	2.20	2.34	2.69	22.3
OKLAHOMA	2.57	2.83	3.22	3.99	41.0
Urban	2.67	3.01	3.43	4.32	43.5
Rural	2.46	2.64	3.00	3.63	37.5
OREGON	1.95	2.21	2.38	3.17	43.4
Urban	1.84	2.28	2.33	3.22	41.2
Rural	2.13	2.11	2.45	3.11	47.4
PENNSYLVANIA	2.37	2.79	3.45	4.02	44.1
Urban	2.45	2.84	3.51	4.09	44.0
Rural	1.87	2.45	3.05	3.58	46.1
WASHINGTON	3.03	3.53	4.22	4.77	35.1
Urban	3.14	3.71	4.29	4.72	27.2
Rural	2.67	2.98	4.01	4.92	65.1
TOTAL	2.46	2.83	3.24	3.69	30.4
Urban	2.48	2.89	3.30	3.75	29.8
Rural	2.40	2.65	3.04	3.49	31.7

Notes: (1) Rates by area are adjusted by age and sex.
(2) Aggregated rates are weighted by the number of Medicare eligibles per individual area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-3

UTILIZATION OF PTCA BY STATE, OVER TIME (USERS PER 1,000 ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	0.56	1.22	2.50	3.04	149.2%
Urban	0.64	1.23	2.62	3.19	159.3
Rural	0.43	1.21	2.32	2.80	130.5
ARIZONA	0.96	1.44	1.84	2.67	85.4
Urban	1.02	1.54	2.03	2.87	86.4
Rural	0.71	1.09	1.18	1.99	82.6
CONNECTICUT	0.47	0.73	1.21	1.82	149.3
WASHINGTON D.C.	0.71	0.99	1.69	2.53	155.1
GEORGIA	0.79	1.20	1.57	2.16	80.0
Urban	0.96	1.48	1.84	2.61	76.4
Rural	0.58	0.85	1.23	1.60	88.2
KANSAS	1.94	2.40	2.71	3.34	39.2
Urban	2.43	2.81	3.03	3.86	37.4
Rural	1.35	1.91	2.32	2.71	41.9
NEW JERSEY	0.38	0.67	1.06	1.62	141.8
OKLAHOMA	0.09	0.62	2.08	2.92	371.0
Urban	0.07	0.61	2.34	3.51	475.4
Rural	0.11	0.64	1.81	2.27	254.7
OREGON	0.78	1.03	1.73	2.27	120.4
Urban	0.77	1.01	1.69	2.33	130.7
Rural	0.80	1.05	1.79	2.17	106.7
PENNSYLVANIA	0.63	1.00	1.46	1.92	92.0
Urban	0.66	1.03	1.48	1.95	89.3
Rural	0.46	0.80	1.29	1.70	112.5
WASHINGTON	0.73	1.52	1.96	2.82	85.5
Urban	0.78	1.55	1.97	2.76	78.1
Rural	0.60	1.44	1.95	3.01	109.0
TOTAL	0.70	1.11	1.68	2.29	106.3
Urban	0.72	1.11	1.67	2.32	109.0
Rural	0.64	1.09	1.71	2.21	102.8

Notes: (1) Rates by area are adjusted by age and sex.
(2) Aggregated rates are weighted by the number of Medicare eligibles per individual area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-4

UTILIZATION OF HEAD CT AND MRI SCANS OVER TIME (users per 1,000 eligibles)

	COMPUTERIZED AXIAL TOMOGRAPHY				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	39.49	43.85	48.74	54.20	23.6%
All Urban	51.47	54.48	59.16	62.42	14.6
Size of MSA					
Less than 125,000	44.52	51.21	58.67	61.74	20.6
125,000 - 250,000	49.15	54.56	58.74	62.93	15.3
250,000 - 500,000	48.46	50.94	54.49	58.29	14.4
500,000 - 1 million	47.22	51.68	56.24	60.20	16.5
Over 1 million	54.77	56.80	61.77	64.46	13.5
All Areas	**48.96**	**52.12**	**56.84**	**60.59**	**16.3**

	MAGNETIC RESONANCE IMAGING				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.07	1.30	2.93	4.95	280.8%
All Urban	0.19	2.50	5.10	7.52	200.8
Size of MSA					
Less than 125,000	0.05	1.41	3.48	5.28	274.5
125,000 - 250,000	0.30	1.72	3.53	6.09	254.1
250,000 - 500,000	0.12	4.21	6.92	8.80	109.0
500,000 - 1 million	0.07	1.83	4.26	6.57	259.0
Over 1 million	0.24	2.56	5.37	7.99	212.1
All Areas	**0.16**	**2.23**	**4.62**	**6.95**	**211.7**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-5

UTILIZATION OF HEAD CT BY STATE, OVER TIME (USERS PER 1,000 ELIGIBLES)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA	48.06	55.09	61.12	69.12	25.5%
Urban	53.09	60.43	65.49	73.53	21.7%
Rural	40.35	46.83	54.28	62.18	32.8%
ARIZONA	43.58	42.63	45.54	48.37	13.5%
Urban	46.71	45.85	47.87	50.94	11.1%
Rural	31.63	31.36	37.56	39.61	26.3%
CONNECTICUT	40.14	45.23	48.37	51.21	13.2%
WASHINGTON D.C.	62.82	52.20	69.82	69.86	33.8%
GEORGIA	49.72	54.79	61.00	68.52	25.1%
Urban	54.25	57.62	64.11	71.33	23.8%
Rural	44.22	51.30	57.13	64.99	26.7%
KANSAS	41.41	47.28	47.37	52.61	11.3%
Urban	50.13	55.59	53.22	57.69	3.8%
Rural	30.88	37.33	40.27	46.49	24.5%
NEW JERSEY	44.94	49.73	53.98	55.12	10.8%
OKLAHOMA	35.88	38.23	42.57	51.65	35.1%
Urban	40.86	42.20	46.53	56.49	33.9%
Rural	30.71	34.11	38.40	46.35	35.9%
OREGON	36.55	39.88	41.94	41.77	4.7%
Urban	38.40	42.62	44.59	44.87	5.3%
Rural	33.43	35.52	38.01	37.30	5.0%
PENNSYLVANIA	58.66	63.12	68.07	71.00	12.5%
Urban	59.87	64.22	69.05	71.94	12.0%
Rural	50.82	56.06	61.73	65.01	16.0%
WASHINGTON	39.12	44.09	47.56	49.86	13.1%
Urban	41.75	45.95	49.69	51.33	11.7%
Rural	31.12	38.39	41.03	45.32	18.1%
TOTAL	48.96	52.12	56.84	60.59	16.3%
Urban	51.47	54.48	59.16	62.42	14.6%
Rural	39.49	43.85	48.74	54.20	23.6%

Notes: (1) Rates by area are adjusted by age and sex.
(2) Aggregated rates are weighted by the number of Medicare eligibles per individual area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-6

UTILIZATION OF HEAD MRI BY STATE, OVER TIME (USERS PER 1,000 ELIGIBLES)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA	0.00	4.05	6.80	8.64	113.3%
Urban	0.00	5.61	9.00	11.24	100.4
Rural	0.01	1.64	3.35	4.56	178.0
ARIZONA	0.02	2.38	7.08	9.43	296.2
Urban	0.02	2.76	8.33	10.41	277.2
Rural	0.00	1.06	2.76	6.09	474.5
CONNECTICUT	0.00	0.38	0.68	2.43	539.5
WASHINGTON D.C.	0.55	3.22	7.30	10.85	237.0
GEORGIA	0.10	0.97	2.29	4.34	347.4
Urban	0.12	1.12	2.51	4.85	333.0
Rural	0.08	0.78	2.01	3.71	375.6
KANSAS	0.09	2.81	5.57	7.59	170.1
Urban	0.14	3.88	6.92	8.91	129.6
Rural	0.03	1.52	3.92	6.01	295.4
NEW JERSEY	0.15	2.20	4.36	6.17	180.5
OKLAHOMA	0.09	1.36	3.59	5.56	308.8
Urban	0.13	1.69	4.74	6.85	305.3
Rural	0.04	1.01	2.37	4.15	310.9
OREGON	0.24	2.80	5.42	7.76	177.1
Urban	0.29	3.31	6.32	9.05	173.4
Rural	0.17	1.99	4.08	5.90	196.5
PENNSYLVANIA	0.26	2.38	4.86	7.88	231.1
Urban	0.29	2.56	5.24	8.31	224.6
Rural	0.11	1.24	2.38	5.13	313.7
WASHINGTON	0.11	2.19	4.45	6.21	183.6
Urban	0.11	2.37	4.65	6.32	166.7
Rural	0.10	1.63	3.83	5.86	259.5
TOTAL	0.16	2.23	4.62	6.95	211.7
Urban	0.19	2.50	5.10	7.52	200.8
Rural	0.07	1.30	2.93	4.95	280.8

Notes: (1) Rates by area are adjusted by age and sex.
(2) Aggregated rates are weighted by the number of Medicare eligibles per individual area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-7

NUMBER OF HEAD CT AND MRI SCANS (per 1,000 eligibles)

	COMPUTERIZED AXIAL TOMOGRAPHY				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	45.19	50.47	56.69	62.83	24.5%
All Urban	61.26	65.44	72.17	75.25	15.0
Size of MSA					
Less than 125,000	50.94	59.13	67.29	72.35	22.4
125,000 - 250,000	57.28	63.95	69.55	73.79	15.4
250,000 - 500,000	57.90	60.99	65.93	69.84	14.5
500,000 - 1 million	55.56	61.83	68.19	73.19	18.4
Over 1 million	65.70	68.76	76.23	77.95	13.4
All Areas	**57.90**	**62.12**	**68.73**	**72.48**	**16.7**

	MAGNETIC RESONANCE IMAGING				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.07	1.33	3.02	5.10	283.5%
All Urban	0.19	2.56	5.33	7.86	207.0
Size of MSA					
Less than 125,000	0.05	1.45	3.55	5.52	280.7
125,000 - 250,000	0.30	1.80	3.67	6.29	249.4
250,000 - 500,000	0.12	4.36	7.17	9.19	110.8
500,000 - 1 million	0.07	1.86	4.38	6.86	268.8
Over 1 million	0.25	2.62	5.66	8.37	219.5
All Areas	**0.16**	**2.29**	**4.81**	**7.25**	**216.6**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-8

NUMBER OF HEAD CT SCANS BY STATE, OVER TIME (PER 1000 ELIGIBLES)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA	56.32	64.81	72.60	82.44	27.2%
Urban	62.78	72.03	78.59	88.37	22.7%
Rural	46.42	53.64	63.23	73.10	36.3%
ARIZONA	48.79	48.67	51.74	55.33	13.7%
Urban	52.43	52.22	54.10	57.84	10.8%
Rural	34.83	36.26	43.66	46.77	29.0%
CONNECTICUT	46.86	53.10	57.50	61.47	15.8%
WASHINGTON D.C.	77.28	64.47	97.72	86.04	33.5%
GEORGIA	59.54	66.28	74.44	79.89	20.5%
Urban	65.65	70.35	78.67	83.52	18.7%
Rural	52.11	61.29	69.17	75.33	22.9%
KANSAS	47.56	53.45	53.61	59.55	11.4%
Urban	58.28	63.44	60.62	65.91	3.9%
Rural	34.63	41.46	45.09	51.68	25.1%
NEW JERSEY	54.28	61.20	67.31	66.40	8.5%
OKLAHOMA	39.64	43.28	48.43	58.76	35.8%
Urban	45.38	48.35	53.80	64.47	33.3%
Rural	33.68	38.00	42.78	52.50	38.2%
OREGON	41.62	45.70	48.07	47.54	4.0%
Urban	44.19	49.34	51.55	51.41	4.2%
Rural	37.30	39.90	42.92	41.97	5.2%
PENNSYLVANIA	70.09	76.64	83.41	88.31	15.2%
Urban	71.89	78.36	85.07	89.89	14.7%
Rural	58.42	65.59	72.76	78.19	19.2%
WASHINGTON	44.19	50.02	54.01	56.68	13.3%
Urban	47.37	52.52	56.61	58.57	11.5%
Rural	34.52	42.36	46.00	50.88	20.1%
TOTAL	57.90	62.12	68.73	72.48	16.7%
Urban	61.26	65.44	72.17	75.25	15.0%
Rural	45.19	50.47	56.69	62.83	24.5%

Notes: (1) Rates by area are adjusted by age and sex.
(2) Aggregated rates are weighted by the number of Medicare eligibles per individual area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-9

NUMBER OF HEAD MRI SCANS BY STATE, OVER TIME (per 1,000 eligibles)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	0.00	4.17	7.04	8.99	115.6
Urban	0.00	5.78	9.32	11.71	102.6
Rural	0.01	1.68	3.47	4.72	181.0
ARIZONA	0.02	2.44	7.26	9.72	298.4
Urban	0.02	2.81	8.56	10.75	282.6
Rural	0.00	1.12	2.83	6.22	455.4
CONNECTICUT	0.00	0.38	0.70	2.48	552.6
WASHINGTON D.C.	0.56	3.37	8.74	11.38	237.7
GEORGIA	0.11	0.99	2.34	4.44	348.5
Urban	0.13	1.15	2.58	4.97	332.2
Rural	0.08	0.79	2.05	3.78	378.5
KANSAS CITY	0.09	2.87	5.70	7.80	171.8
Urban	0.14	3.95	7.08	9.16	131.9
Rural	0.03	1.57	4.03	6.17	293.0
NEW JERSEY	0.15	2.24	4.45	6.38	184.8
OKLAHOMA	0.09	1.39	3.68	5.69	309.4
Urban	0.14	1.74	4.89	7.00	302.3
Rural	0.04	1.04	2.41	4.25	308.7
OREGON	0.24	2.83	5.57	7.95	180.9
Urban	0.29	3.35	6.48	9.25	176.1
Rural	0.17	1.99	4.21	6.08	205.5
PENNSYLVANIA	0.27	2.45	5.06	8.38	242.0
Urban	0.29	2.63	5.46	8.85	236.5
Rural	0.12	1.28	2.46	5.37	319.5
WASHINGTON	0.11	2.26	4.59	6.45	185.4
Urban	0.11	2.46	4.79	6.58	167.5
Rural	0.10	1.64	3.96	6.07	270.1
TOTAL	0.16	2.29	4.81	7.25	216.6
Urban	0.19	2.56	5.33	7.86	207.0
Rural	0.07	1.32	3.02	5.10	283.5

Notes: (1) Rates by area are adjusted by age and sex.
(2) Aggregated rates are weighted by the number of Medicare eligibles per individual area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-10

UTILIZATION OF SURGICAL STONE REMOVAL PROCEDURES AND ESWL OVER TIME (users per 1,000 eligibles)

	SURGICAL METHODS OF STONE REMOVAL				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	1.12	1.10	1.17	1.47	33.6%
All Urban	0.99	1.01	1.09	1.29	27.7
Size of MSA					
Less than 125,000	1.39	1.43	1.56	1.51	5.6
125,000 - 250,000	1.09	1.17	1.23	1.29	10.3
250,000 - 500,000	0.10	0.93	1.07	0.98	5.4
500,000 - 1 million	0.96	1.02	1.13	1.33	30.4
Over 1 million	0.97	0.97	1.03	1.33	37.1
All Areas	**1.02**	**1.03**	**1.11**	**1.32**	**28.2**

	EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.02	0.31	0.53	0.55	77.4%
All Urban	0.01	0.22	0.45	0.52	136.4
Size of MSA					
Less than 125,000	0.02	0.43	0.72	0.68	58.1
125,000 - 250,000	0.01	0.25	0.51	0.48	92.0
250,000 - 500,000	0.00	0.39	0.61	0.52	33.3
500,000 - 1 million	0.00	0.20	0.39	0.45	125.0
Over 1 million	0.01	0.18	0.42	0.56	211.1
All Areas	**0.01**	**0.24**	**0.47**	**0.53**	**120.8**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-11

UTILIZATION OF SURGICAL STONE REMOVAL PROCEDURES BY STATE, OVER TIME (USERS PER 1,000 ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	1.11	1.28	1.49	1.76	37.5%
Urban	1.10	1.18	1.45	1.59	34.7%
Rural	1.13	1.42	1.55	2.03	43.0%
ARIZONA	1.07	0.72	0.78	1.29	79.2%
Urban	1.16	0.72	0.79	1.35	87.5%
Rural	0.72	0.75	0.74	1.10	46.7%
CONNECTICUT	0.82	0.91	1.13	1.12	23.1%
WASHINGTON D.C.	0.88	0.75	0.87	1.07	42.7%
GEORGIA	1.22	1.32	1.43	1.41	6.8%
Urban	1.12	1.30	1.39	1.27	-2.3%
Rural	1.35	1.34	1.47	1.60	19.4%
KANSAS	1.04	1.09	1.07	1.25	14.7%
Urban	1.02	1.08	1.19	1.27	17.6%
Rural	1.07	1.10	0.93	1.24	12.7%
NEW JERSEY	0.85	0.93	0.97	1.10	18.3%
OKLAHOMA	0.98	0.86	1.07	1.35	57.0%
Urban	1.03	0.93	1.13	1.32	41.9%
Rural	0.93	0.77	1.00	1.38	79.2%
OREGON	0.64	0.67	0.77	1.02	52.2%
Urban	0.59	0.67	0.79	0.89	32.8%
Rural	0.72	0.66	0.74	1.21	83.3%
PENNSYLVANIA	1.17	1.18	1.22	1.60	35.6%
Urban	1.14	1.18	1.20	1.59	34.7%
Rural	1.33	1.20	1.36	1.68	40.0%
WASHINGTON	0.76	0.78	0.78	0.72	-7.7%
Urban	0.76	0.71	0.75	0.66	-7.0%
Rural	0.75	1.00	0.88	0.91	-9.0%
TOTAL	1.02	1.03	1.11	1.32	28.2
Urban	0.99	1.01	1.09	1.29	27.7
Rural	1.12	1.10	1.17	1.47	33.6

Notes: (1) Rates by area are adjusted by age and sex.
(2) Aggregated rates are weighted by the number of Medicare eligibles per individual area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-12

UTILIZATION OF ESWL BY STATE, OVER TIME (USERS PER 1,000 ELIGIBLES)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA	0.00	0.69	0.82	0.77	11.4%
Urban	0.00	0.75	0.85	0.69	-7.5
Rural	0.00	0.60	0.78	0.89	47.8
ARIZONA	0.00	0.00	0.51	0.56	--
Urban	0.00	0.00	0.55	0.61	--
Rural	0.00	0.00	0.37	0.42	--
CONNECTICUT	0.00	0.00	0.01	0.08	--
WASHINGTON D.C.	0.00	0.24	0.53	0.49	105.0
GEORGIA	0.07	0.65	0.79	0.78	19.7
Urban	0.08	0.69	0.82	0.81	17.4
Rural	0.07	0.61	0.76	0.74	22.3
KANSAS	0.00	0.34	0.56	0.54	58.8
Urban	0.00	0.38	0.61	0.55	44.4
Rural	0.00	0.28	0.51	0.52	86.5
NEW JERSEY	0.00	0.13	0.24	0.49	288.8
OKLAHOMA	0.00	0.16	0.46	0.35	120.4
Urban	0.00	0.17	0.47	0.40	131.2
Rural	0.00	0.14	0.44	0.29	102.8
OREGON	0.00	0.08	0.34	0.36	346.3
Urban	0.00	0.08	0.41	0.35	333.7
Rural	0.01	0.07	0.23	0.37	418.1
PENNSYLVANIA	0.00	0.18	0.45	0.54	198.9
Urban	0.00	0.18	0.45	0.56	211.0
Rural	0.00	0.19	0.43	0.42	123.8
WASHINGTON	0.00	0.16	0.50	0.55	244.0
Urban	0.00	0.17	0.53	0.57	233.3
Rural	0.00	0.12	0.42	0.48	291.8
TOTAL	0.01	0.24	0.47	0.53	120.8
Urban	0.01	0.22	0.45	0.52	136.4
Rural	0.02	0.31	0.53	0.55	77.4

Notes: (1) Rates by area are adjusted by age and sex.
(2) Aggregated rates are weighted by the number of Medicare eligibles per individual area.

Source: 100% Medicare Claims from 11 States.

TABLE 4-13

MEAN UTILIZATION RATES FOR LOW, AVERAGE, AND HIGH USE AREAS (users per 1,000 eligibles)

	Number of Areas	*MEAN UTILIZATION RATE* 1985	1986	1987	1988	Percent Change 1986-1988
CABG						
Low Use	23	1.47	1.92	2.20	2.76	43.8%
Average Use	49	2.39	2.71	3.13	3.62	33.6
High Use	23	3.62	4.03	4.46	4.69	16.4
PTCA						
Low Use	24	0.21	0.44	1.33	1.83	315.9
Average Use	48	0.59	0.96	1.50	2.10	118.8
High Use	23	1.35	2.10	2.55	3.24	54.3
CT						
Low Use	23	33.58	37.00	40.63	44.71	20.8
Average Use	48	46.38	49.40	54.72	57.83	17.1
High Use	24	60.24	66.15	70.33	75.04	13.4
MRI						
Low Use	24	0.04	0.47	1.46	3.57	659.6
Average Use	47	0.08	1.43	3.58	5.66	295.8
High Use	24	0.29	3.92	7.15	9.87	151.8
SURGICAL STONE REMOVAL PROCEDURES						
Low Use	24	0.82	0.64	0.79	0.95	48.4
Average Use	48	0.98	1.00	1.08	1.32	32.0
High Use	23	1.34	1.55	1.56	1.77	14.2
ESWL						
Low Use	24	0.00	0.02	0.29	0.45	2,150.0
Average Use	48	0.00	0.19	0.43	0.48	152.6
High Use	23	0.04	0.67	0.81	0.78	16.4

Note: There were too few areas with any use in 1985 of the three new technologies. Therefore, utilization rates were classified as high/medium/low based on 1986 levels.

Source: 100% Medicare claims from 11 states (95 area groupings).

FIGURE 4-1

Diffusion of CABG Surgery and PTCA by Baseline Rates

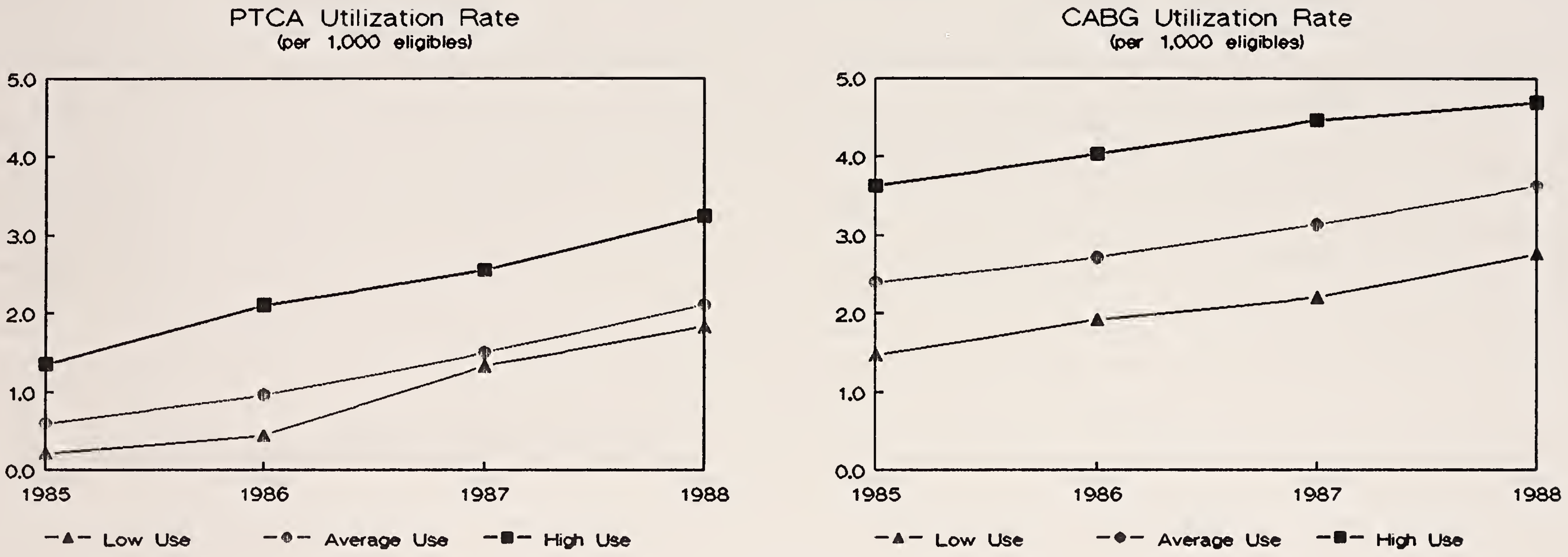


FIGURE 4-2

Diffusion of CT and MRI by Baseline Rates

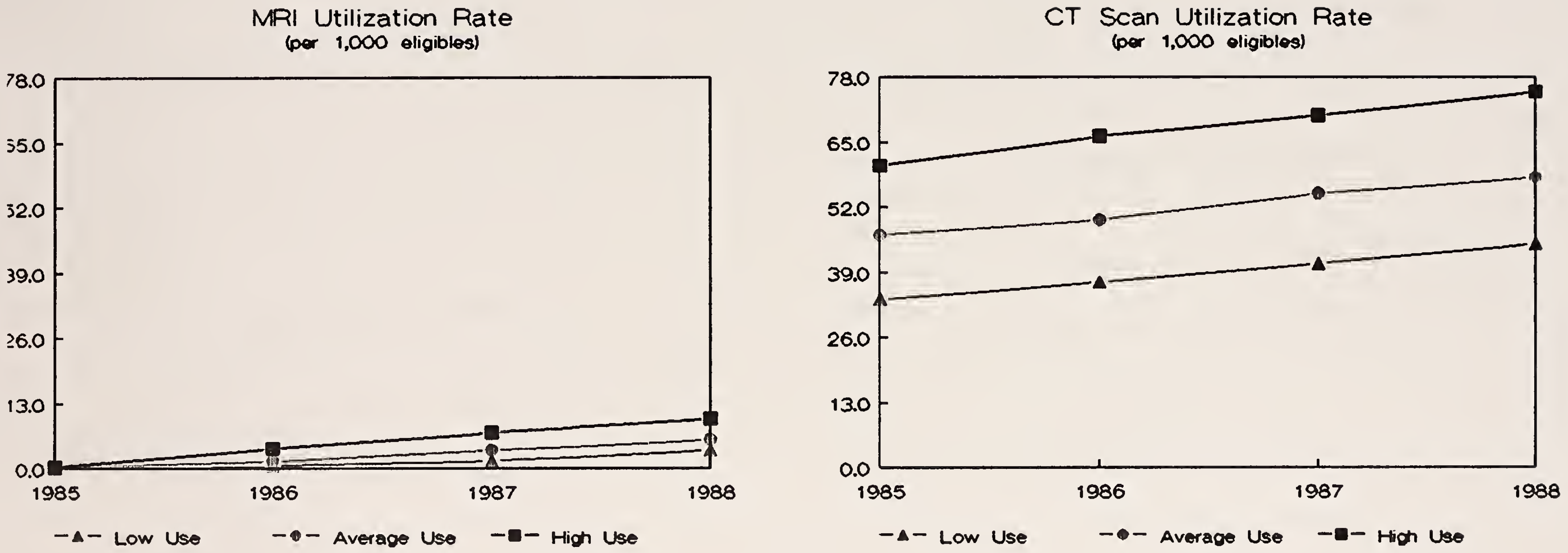
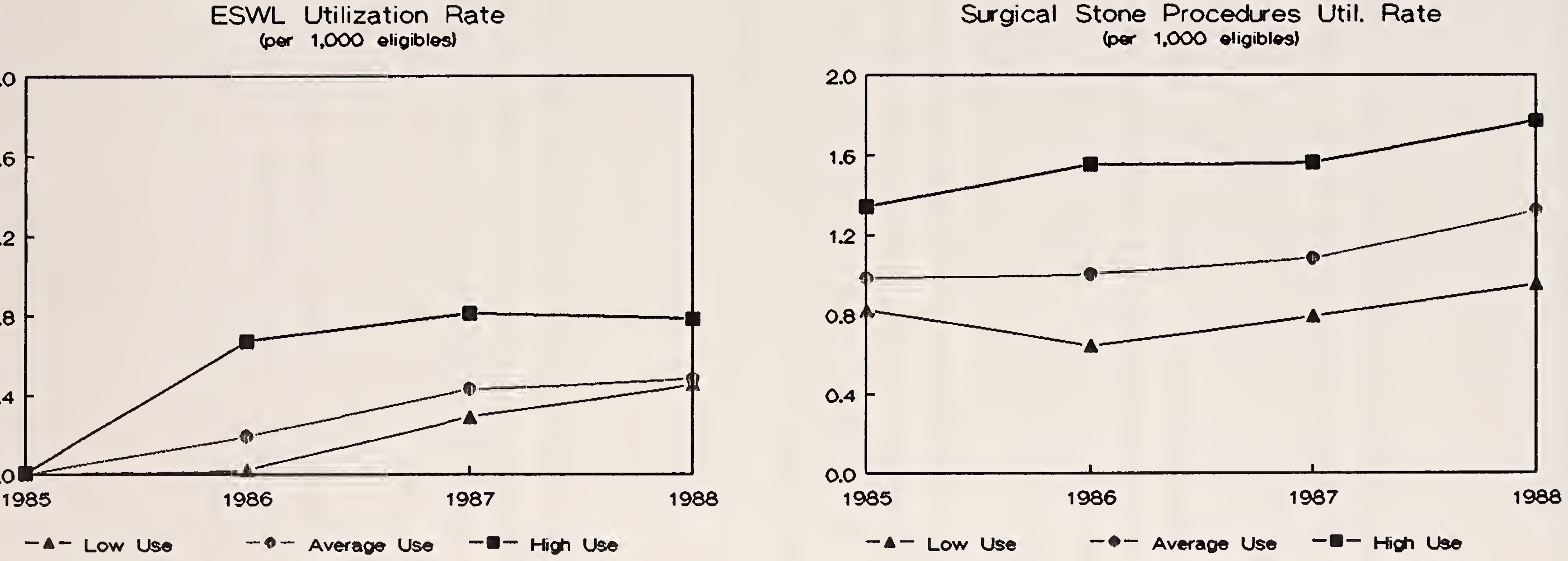


FIGURE 4-3

Diffusion of Surgical Stone Removal and ESWL by Baseline Rates



ESWL Utilization Rate (per 1,000 eligibles)

Surgical Stone Procedures Util. Rate (per 1,000 eligibles)

5.0 UTILIZATION TRENDS BY BLACK AND WHITE ELIGIBLES OVER TIME

5.1 Introduction

Our Chapter 3 findings, based on the BMAD beneficiary files, showed pronounced white-black differentials in use; for five of the six technologies, utilization by black Medicare eligibles was significantly below that of white eligibles. There was no evidence, furthermore, that the gap was narrowing appreciably over time. The five percent sample used in the BMAD files was too small to permit black-white comparisons at the subnational level, however, and it is possible that black Medicare beneficiaries are disproportionately located in rural areas, which have not yet adopted the newer technologies. If so, this might be one explanation for the lower utilization rates observed for black Medicare eligibles. In this chapter, we seek to examine black-white differences in use at the small area level.

To do this, we draw upon the same Multi-State data base used in Chapter 4. Because this data base includes the universe of all Medicare eligibles, we have sufficient numbers of black beneficiaries to support the analysis of utilization differences not only by state but also at the sub-state level (e.g. urban vs. rural within-state). In the following section, we describe our study population in more detail.

5.2 Study Population and Methods

Just over nine percent of the Medicare eligible population in our eleven states are black, for a total of 574,276. As shown in Table 5-1, however, those eligibles are primarily concentrated in just five states: Alabama, the District of Columbia, Georgia, New Jersey, and Pennsylvania contain 87 percent of black Medicare beneficiaries. Because the small numbers of black eligibles in the remaining six states sometimes result in random rate variation from year to year, we focus much of our analysis on the "big five".

For each technology, we first compare black and white utilization rates over time by MSA size and rural location. These comparisons are based on all eleven states. We then

present state-specific urban-rural comparisons for the five states with the largest numbers of black eligibles. Comparable comparisons for all states can be found in Appendix A; the reader is cautioned, however, that some rates in the appendix tables are based on an exceedingly small number of procedures.

Returning to Table 5-1, it should be noted that black Medicare eligibles residing in our eleven states are not disproportionately located in rural areas. In fact, they are actually most likely to live in the very largest MSAs; one-half of black eligibles (49.5%) live in MSAs with more than one million population, compared with 39.5 percent of white eligibles. Again, this partly reflects the relative distributions of white and black beneficiaries across our eleven states.*

All utilization rates shown in this chapter have been adjusted for age and sex differences. Because the utilization rates are based on the universe of Medicare enrollees residing in these areas, no significant testing of differences needed to be performed. Instead, we evaluate the differences according to whether or not they are meaningful. If the differences are sufficiently large (e.g. varying by a multiple), that might suggest evidence of unequal access to technology. On the other hand, if the differences are sufficiently small (e.g., no more than 20 or 30 percent), then they could be attributed to other legitimate factors, such as black/white differences in disease incidence.

5.3 Differential Use of CABG Surgery and PTCA

White Medicare eligibles in our eleven states undergo CABG surgery at more than twice the rate of black eligibles (see Table 5-2); this differential has remained unchanged over the four year time period. Utilization rates are higher for whites in both urban and rural areas, with the gap most noticeable in the very largest MSAs (over one million population).

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*MSAs with greater than one million population in our 11 states are Phoenix, Hartford, Atlanta, Kansas City, Bergen-Passaic, Newark, Philadelphia, Pittsburg, Portland, Seattle, and Washington D.C.

The race differential persists for each of the states shown in Table 5-3. Black Medicare eligibles undergo CABG surgery at only a fraction of the rate of white eligibles living in similar (urban or rural) areas of the same state. By 1988, the differential ranged from roughly 2-to-1 (District of Columbia and rural Pennsylvania) to more than 4-to-1 (rural Alabama and rural Georgia). While utilization rates grew for both whites and blacks during this time period, there is no consistent evidence that the differential is closing over time. In Alabama, which has the highest absolute level of CABG surgery among our eleven states, urban white eligibles were 4.5 times more likely to undergo bypass surgery in 1985 compared with urban blacks. By 1988, the gap had narrowed to 3.3, still a major differential. Among urban Pennsylvania residents, the gap actually grew over the same time period.

Similar patterns are observed for PTCA, which white eligibles were more than twice as likely as blacks to receive, as of 1988 (Table 5-4). In Chapter 4, we saw that the District of Columbia and Georgia were both apparently early adopters of PTCA; their 1985 rates were well above the national average of 0.74 (0.95 and 0.98, respectively). From Table 5-5, however, we see that it was largely white residents of these states that took advantage of this early access; even by 1988, utilization rates of black residents of D.C. and Georgia lagged well behind those of their white peers. The PTCA gap is particularly noticeable in Alabama, where white eligibles are more than four times more likely than blacks to receive angioplasty.

5.4 Differential Use of CT and MRI

Our BMAD analysis showed substantially higher rates of CT scans among black Medicare beneficiaries nationally, the only one of the six technologies in which this occurred. We observe this pattern in our eleven states as well, although the differential is most pronounced in urban areas (Table 5-6). Despite their higher baseline levels, furthermore, utilization rates for black eligibles are actually increasing faster than those for white eligibles in both urban and rural areas. Not only is the CT user rate growing more rapidly for blacks, but the absolute number of scans as well (Table 5-7).

This marked use of CT scans by black Medicare eligibles is not observed across all states, however (see Table 5-8). Utilization rates for Alabama and Georgia residents are roughly equivalent for white and black eligibles. The remaining areas, all relatively urban and in the Northeast (New Jersey, Pennsylvania, and D.C.), exhibit more pronounced black-white utilization differences, basically similar to those of the nation as a whole.

Geographic proximity to new technologies has been suggested as one possible reason for higher MRI utilization rates by whites. If so, then we would expect black and white rates to be more similar in the urban areas. Even in the largest MSAs, however, black Medicare eligibles are less likely to receive MRI scans (Table 5-9). From Table 5-10, however, we can see that there is considerable variation by state. Based on their 1985 use levels, D.C. and urban Pennsylvania were among the first adopters of MRI technology. Although black utilization rates have lagged behind those of whites, there does appear to be considerable "catching up" over time, especially in urban Pennsylvania where by 1988 black and white rates are roughly equivalent.

Alabama is an interesting case-study. There were virtually no MRI scans performed on its Medicare population in 1985, but by 1986 utilization rates for urban blacks and urban whites were already more than twice the national average (even though the black Alabama rate was only one-half that of the white Alabama rate). MRI utilization by black eligibles continued to lag behind that of whites in Alabama, and by 1988 the difference had narrowed only slightly. Nevertheless, urban black rates in Alabama were still higher than the U.S. average in 1988 (7.57 versus 6.91 per 1,000).

5.5 Differential Use of Surgical Stone Removal and Lithotripsy

As seen in Table 5-11, black Medicare eligibles have consistently had lower use rates of surgical stone removal than whites in both urban and rural areas. This is not an artifact of where black Medicare beneficiaries live; we observe the same pattern in all five of the states shown in Table 5-12.

White Medicare eligibles also are more likely to undergo ESWL than comparable black eligibles (Table 5-13). In fact, the white-black gap is considerably larger here than found with

a national sample; given the relatively low use rates of lithotripsy among both blacks and whites, however, this difference should be treated with caution.

Urinary stones are more common in the South where the drinking water is soft, and we saw in Chapter 4 that ESWL rates were above average in Alabama and Georgia. Based on Table 5-14, however, it would appear that ESWL is more likely to be performed on white eligibles in those states than on blacks. Black lithotripsy rates continue to lag behind those of whites in both Alabama and Georgia. In fact, black utilization rates in those two states are not appreciably different from the national average for blacks (0.40 in 1988). By contrast, white rates in Alabama and Georgia are considerably higher than the national average for whites (0.55).

5.6 A Tale of Five Cities

It is possible that our comparisons of urban white and urban black eligibles within a state actually represent very different types of urban areas. Urban black residents of Alabama, for example, may be disproportionately located in smaller MSAs, like Montgomery and Tuscaloosa, while urban whites may be more likely to live in Birmingham where they enjoy easier access to new technology. If so, this might explain some of the unexplained within-state differences between white and black Medicare eligibles.

To further control for MSA size (and, implicitly, the availability of technology), we compared black-white differences in use for five large MSAs, one from each of the top five states: Atlanta, Birmingham, Newark, Philadelphia, and Washington, D.C. Tables 5-15 and 5-16 present results for CABG surgery and PTCA, respectively. (Similar tables of the other four technologies yielded similar patterns.)

Large utilization differences persist, even when we examine these cities individually. White residents of Atlanta, for example, undergo both bypass surgery and PTCA at more than four times the rates of black residents of similar age and gender. While the percentage increase in utilization over time is often larger for blacks than for whites, this is largely a function of their much lower absolute use levels to start with. There is no evidence from these tables that the use "gap" will be closing in the near future.

TABLE 5-1

DISTRIBUTION OF WHITE AND BLACK MEDICARE ELIGIBLES, BY URBAN/RURAL AND STATE[a]

	Total Eligibles	White Eligibles	Black Eligibles
TOTAL	100.0%	100.0%	100.0%
State			
Alabama	7.9	6.8	19.1
Arizona	5.9	6.3	1.2
Connecticut	6.0	6.3	2.7
Washington, D.C.	3.8	3.0	10.5
Georgia	10.1	8.5	25.1
Kansas	6.5	6.9	3.9
New Jersey	13.2	13.3	11.3
Oklahoma	5.9	6.0	3.3
Oregon	4.7	5.4	0.5
Pennsylvania	28.2	29.1	21.0
Washington	7.8	8.4	1.4
MSA Size			
Rural	22.3	22.5	19.7
Less than 250,000	8.2	8.2	8.3
250,000 to 1 million	29.1	29.7	22.4
Over 1 million	40.4	39.5	49.6

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[a] Eligibility frequencies were calculated from 1988 Medicare enrollment files; MSA size was based on 1980 Census population.

TABLE 5-2

UTILIZATON OF CABG SURGERY BY WHITES AND BLACKS (users per 1,000 eligibles)

	WHITES				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	2.74	2.96	3.38	3.86	30.4%
Size of MSA					
Less than 250,000	3.26	3.53	4.09	4.53	28.3
250,000 - 1 million	2.85	3.40	3.79	4.20	23.5
Over 1 million	2.72	3.12	3.55	4.13	32.4
All Areas	**2.81**	**3.20**	**3.63**	**4.12**	**28.8**

	BLACKS				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	1.03	0.84	1.51	2.70	221.4%
Size of MSA					
Less than 250,000	0.64	0.82	0.99	1.93	135.4
250,000 - 1 million	1.38	1.26	3.79	4.20	233.3
Over 1 million	1.29	1.14	1.22	1.54	35.1
All Areas	**1.31**	**1.09**	**1.40**	**1.78**	**63.3**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 5-3

UTILIZATION OF CABG SURGERY BY BLACKS AND WHITES, BY STATE, OVER TIME (users per 1,000 eligibles)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA					
White Urban	5.16	5.46	5.89	5.98	9.5%
Black Urban	1.15	1.27	1.60	1.83	44.5%
White Rural	4.69	4.72	5.07	5.23	10.8%
Black Rural	0.81	0.90	0.91	1.23	36.7%
WASHINGTON D.C.					
White Urban	3.32	2.96	2.97	3.58	21.0%
Black Urban	1.40	0.87	1.72	1.78	103.8%
GEORGIA					
White Urban	3.75	3.91	4.30	4.88	24.8%
Black Urban	0.77	0.89	1.21	1.16	29.9%
White Rural	2.45	2.80	3.11	3.38	20.7%
Black Rural	0.28	0.59	0.54	0.76	28.5%
NEW JERSEY					
White Urban	1.46	2.44	2.57	2.96	21.6%
Black Urban	0.75	0.93	0.98	1.27	36.9%
PENNSYLVANIA					
White Urban	2.71	3.16	3.87	4.51	42.9%
Black Urban	1.13	1.12	1.79	1.48	32.2%
White Rural	1.95	2.57	3.17	3.73	45.5%
Black Rural	1.07	1.04	3.26	2.01	93.5%

Note: Rates are adjusted by age and sex at the area level.

Source: 100% Medicare Part B claims.

TABLE 5-4

UTILIZATON OF PTCA SURGERY BY WHITES AND BLACKS (users per 1,000 eligibles)

	WHITES				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.70	1.21	1.89	2.43	100.8%
Size of MSA					
Less than 250,000	0.65	1.06	1.71	2.51	136.8
250,000 - 1 million	0.77	1.20	1.96	2.53	110.8
Over 1 million	0.86	1.34	1.84	2.64	97.0
All Areas	**0.78**	**1.25**	**1.88**	**2.55**	**104.0**

	BLACKS				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.18	0.07	0.33	1.01	1,342.9%
Size of MSA					
Less than 250,000	0.16	1.18	1.20	2.19	85.6
250,000 - 1 million	0.32	0.40	0.88	0.82	105.0
Over 1 million	0.32	0.45	0.69	1.01	124.4
All Areas	**0.28**	**0.40**	**0.71**	**1.05**	**162.5**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 5-5

UTILIZATION OF PTCA BY BLACKS AND WHITES, BY STATE, OVER TIME (users per 1,000 eligibles)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA					
White Urban	0.84	1.59	3.31	4.05	155.2%
Black Urban	0.15	0.34	0.88	0.82	144.2%
White Rural	0.55	1.51	2.87	3.42	126.4%
Black Rural	0.09	0.33	0.44	0.77	137.4%
WASHINGTON D.C.					
White Urban	0.95	1.28	2.18	3.05	138.1%
Black Urban	0.31	0.38	0.79	1.43	274.1%
GEORGIA					
White Urban	1.19	1.88	2.31	3.30	75.3%
Black Urban	0.38	0.48	0.60	0.82	69.8%
White Rural	0.72	1.10	1.56	1.96	78.9%
Black Rural	0.13	0.10	0.21	0.44	335.3%
NEW JERSEY					
White Urban	0.41	0.75	1.14	1.76	135.4%
Black Urban	0.17	0.31	0.54	0.85	177.2%
PENNSYLVANIA					
White Urban	0.72	1.12	1.60	2.11	88.1%
Black Urban	0.34	0.45	0.81	0.76	71.0%
White Rural	0.48	0.83	1.33	1.75	111.3%
Black Rural	0.00	0.00	0.00	0.35	--

Note: Rates are adjusted by age and sex at the area level.

Source: 100% Medicare Part B claims.

TABLE 5-6

UTILIZATON OF CT BY WHITES AND BLACKS (users per 1,000 eligibles)

	WHITES				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	40.98	44.92	50.05	55.39	23.3%
Size of MSA					
Less than 250,000	48.88	54.38	59.30	62.89	15.6
250,000 - 1 million	48.43	52.14	56.07	60.05	15.2
Over 1 million	54.12	56.92	60.50	63.09	10.8
All Areas	**49.29**	**52.67**	**56.79**	**60.47**	**14.8**

	BLACKS				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	44.08	40.30	49.67	59.01	46.4%
Size of MSA					
Less than 250,000	68.84	56.69	68.83	70.67	24.7
250,000 - 1 million	63.04	57.46	65.78	72.22	25.7
Over 1 million	75.10	65.63	74.54	79.21	20.7
All Areas	**64.68**	**56.98**	**66.08**	**71.97**	**26.3**

Notes:
(1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 5-7

UTILIZATON OF CT SCANS BY WHITES AND BLACKS (claims per 1,000 eligibles)

	WHITES				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	46.91	51.51	58.11	64.12	24.5%
Size of MSA					
Less than 250,000	56.69	63.39	69.42	73.37	15.7
250,000 - 1 million	57.23	62.23	67.79	72.50	16.5
Over 1 million	64.51	68.56	74.08	75.83	10.6
All Areas	**58.08**	**62.53**	**68.32**	**72.05**	**15.2**

	BLACKS				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	49.66	48.63	57.00	68.89	41.7%
Size of MSA					
Less than 250,000	78.82	65.20	81.43	83.96	28.8
250,000 - 1 million	75.59	72.03	81.50	89.32	24.0
Over 1 million	93.15	82.11	95.95	99.14	20.7
All Areas	**77.91**	**70.50**	**82.02**	**88.29**	**25.2**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 5-8

UTILIZATION OF CT SCANS BY BLACKS AND WHITES, BY STATE, OVER TIME (users per 1,000 eligibles)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA					
White Urban	54.79	62.75	67.01	75.27	19.9%
Black Urban	50.94	56.47	63.82	73.26	29.7%
White Rural	43.58	49.88	58.02	65.89	32.1%
Black Rural	31.31	38.60	43.90	53.00	37.3%
WASHINGTON D.C.					
White Urban	57.89	56.52	62.73	63.00	11.5%
Black Urban	85.03	44.79	96.20	95.46	113.1%
GEORGIA					
White Urban	55.89	59.22	65.82	72.09	21.7%
Black Urban	54.25	58.27	64.37	76.01	30.4%
White Rural	46.82	53.50	59.95	67.03	25.3%
Black Rural	38.24	46.54	50.90	63.02	35.4%
NEW JERSEY					
White Urban	44.74	49.62	53.29	54.91	10.7%
Black Urban	57.55	61.53	68.45	67.08	9.0%
PENNSYLVANIA					
White Urban	59.99	64.24	68.81	71.44	11.2%
Black Urban	72.12	74.72	86.07	93.06	24.5%
White Rural	51.30	56.53	62.31	65.57	16.0%
Black Rural	47.35	58.08	70.55	66.57	14.6%

Note: Rates are adjusted by age and sex at the area level.

Source: 100% Medicare Part B claims.

TABLE 5-9

UTILIZATON OF MRI BY WHITES AND BLACKS (users per 1,000 eligibles)

	WHITES				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.07	1.36	3.09	5.18	280.9%
Size of MSA					
Less than 250,000	0.22	1.72	3.65	6.11	255.2
250,000 - 1 million	0.09	2.85	5.51	7.76	172.3
Over 1 million	0.26	2.75	5.62	8.28	201.1
All Areas	**0.17**	**2.39**	**4.87**	**7.26**	**203.8**

	BLACKS				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.01	0.95	1.72	4.04	325.3%
Size of MSA					
Less than 250,000	0.18	0.96	5.61	3.34	247.9
250,000 - 1 million	0.80	1.95	3.73	6.18	216.9
Over 1 million	0.22	1.59	3.85	6.40	302.5
All Areas	**0.34**	**1.50**	**3.49**	**5.56**	**270.7**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 5-10

UTILIZATION OF MRI BY BLACKS AND WHITES, BY STATE, OVER TIME (users per 1,000 eligibles)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA					
White Urban	0.00	6.49	10.33	12.78	96.9%
Black Urban	0.00	3.39	5.55	7.57	123.4%
White Rural	0.01	1.83	3.79	5.14	180.8%
Black Rural	0.00	1.09	1.87	2.82	159.2%
WASHINGTON D.C.					
White Urban	0.67	4.04	8.33	11.73	190.1%
Black Urban	0.29	1.25	5.25	9.39	648.2%
GEORGIA					
White Urban	0.15	1.29	2.90	5.49	326.7%
Black Urban	0.05	0.86	1.53	3.48	304.6%
White Rural	0.09	0.84	2.22	4.09	384.7%
Black Rural	0.05	0.57	1.27	2.74	383.8%
NEW JERSEY					
White Urban	0.15	2.33	4.52	6.42	175.7%
Black Urban	0.08	1.80	3.83	4.58	154.1%
PENNSYLVANIA					
White Urban	0.28	2.68	5.42	8.57	219.9%
Black Urban	0.23	2.17	4.74	8.01	269.9%
White Rural	0.12	1.27	2.44	5.18	308.2%
Black Rural	0.00	1.01	0.61	2.99	194.3%

Note: Rates are adjusted by age and sex at the area level.

Source: 100% Medicare Part B claims.

TABLE 5-11

UTILIZATON OF SURGICAL STONE REMOVAL BY WHITES AND BLACKS (users per 1,000 eligibles)

	WHITES				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	1.22	1.19	1.29	1.59	33.6%
Size of MSA					
Less than 250,000	1.28	1.35	1.45	1.48	9.6
250,000 - 1 million	1.04	1.06	1.19	1.31	23.6
Over 1 million	1.06	1.07	1.12	1.43	33.6
All Areas	**1.11**	**1.12**	**1.21**	**1.43**	**27.7**

	BLACKS				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.69	0.36	0.31	1.28	255.6%
Size of MSA					
Less than 250,000	0.59	0.61	0.66	0.52	-14.8
250,000 - 1 million	0.75	1.02	0.99	0.41	-59.8
Over 1 million	0.83	0.65	0.67	1.11	70.8
All Areas	**0.76**	**0.69**	**0.68**	**0.90**	**30.4**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 5-12

UTILIZATION OF SURGICAL STONE REMOVAL BY BLACKS AND WHITES, BY STATE, OVER TIME (users per 1,000 eligibles)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA					
White Urban	1.25	1.36	1.72	1.88	37.7%
Black Urban	0.67	0.77	0.64	0.92	19.5%
White Rural	1.27	1.61	1.84	2.34	44.9%
Black Rural	0.74	0.84	0.62	1.03	22.6%
WASHINGTON D.C.					
White Urban	1.02	0.90	1.01	1.18	31.5%
Black Urban	0.67	0.43	0.59	0.97	125.6%
GEORGIA					
White Urban	1.33	1.53	1.60	1.49	-2.8%
Black Urban	0.67	0.76	0.94	0.79	3.9%
White Rural	1.57	1.52	1.69	1.81	19.5%
Black Rural	0.68	0.92	0.91	1.04	13.0%
NEW JERSEY					
White Urban	0.90	0.99	1.01	1.18	18.2%
Black Urban	0.74	0.72	1.05	0.83	15.3%
PENNSYLVANIA					
White Urban	1.23	1.25	1.29	1.69	34.7%
Black Urban	0.81	1.29	0.97	0.86	-33.5%
White Rural	1.39	1.23	1.40	1.73	40.1%
Black Rural	0.32	0.00	0.00	0.67	--

Note: Rates are adjusted by age and sex at the area level.

Source: 100% Medicare Part B claims.

TABLE 5-13

UTILIZATON OF ESWL BY WHITES AND BLACKS (users per 1,000 eligibles)

	WHITES				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.02	0.35	0.59	0.64	82.9%
Size of MSA					
Less than 250,000	0.02	0.34	0.64	0.62	82.4
250,000 - 1 million	0.00	0.31	0.51	0.31	0.0
Over 1 million	0.01	0.20	0.46	0.63	215.0
All Areas	**0.01**	**0.28**	**0.52**	**0.61**	**117.9**

	BLACKS				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.00	0.12	0.40	0.40	233.3%
Size of MSA					
Less than 250,000	0.00	0.12	0.24	0.18	50.0
250,000 - 1 million	0.00	0.08	0.15	0.25	212.5
Over 1 million	0.00	0.12	0.27	0.38	216.7
All Areas	**0.00**	**0.11**	**0.26**	**0.33**	**200.0**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE 5-14

UTILIZATION OF ESWL BY BLACKS AND WHITES, BY STATE, OVER TIME (users per 1,000 eligibles)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA					
White Urban	0.00	0.92	1.02	0.85	-8.4%
Black Urban	0.00	0.26	0.49	0.31	19.2%
White Rural	0.00	0.70	0.89	1.01	43.6%
Black Rural	0.00	0.31	0.40	0.61	96.8%
WASHINGTON D.C.					
White Urban	0.00	0.31	0.60	0.52	68.6%
Black Urban	0.00	0.13	0.40	0.47	273.0%
GEORGIA					
White Urban	0.09	0.84	0.97	1.11	33.1%
Black Urban	0.04	0.34	0.47	0.54	58.8%
White Rural	0.07	0.71	0.90	0.98	37.6%
Black Rural	0.03	0.23	0.36	0.48	108.7%
NEW JERSEY					
White Urban	0.00	0.14	0.26	0.52	275.5%
Black Urban	0.00	0.05	0.10	0.23	360.0%
PENNSYLVANIA					
White Urban	0.00	0.20	0.48	0.61	210.5%
Black Urban	0.00	0.07	0.26	0.33	371.4%
White Rural	0.00	0.20	0.44	0.43	118.9%
Black Rural	0.00	0.00	0.97	1.02	--

Note: Rates are adjusted by age and sex at the area level.

Source: 100% Medicare Part B claims.

TABLE 5-15

TRENDS IN CABG SURGERY AMONG WHITE AND BLACK MEDICARE ELIGIBLES IN FIVE CITIES (users per 1,000 eligibles)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
Atlanta, GA					
White	3.72	3.80	4.12	4.57	20.3%
Black	0.74	0.87	1.30	1.03	18.4
Birmingham, AL					
White	5.90	6.18	6.53	6.97	12.8
Black	1.56	1.43	1.96	1.87	30.8
Newark, NJ					
White	1.21	2.54	2.45	2.78	9.4
Black	0.56	0.80	0.76	1.06	32.5
Philadelphia, PA					
White	2.83	3.28	4.12	4.86	48.2
Black	0.98	1.03	1.46	1.53	48.5
Washington, D.C.					
White	3.32	2.96	2.97	3.58	20.9
Black	1.40	0.87	1.72	1.78	104.6

Source: 100% Medicare claims files.

TABLE 5-16

TRENDS IN PTCA AMONG WHITE AND BLACK MEDICARE ELIGIBLES IN FIVE CITIES (users per 1,000 eligibles)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
Atlanta, GA					
White	1.12	2.06	2.41	3.58	73.8%
Black	0.46	0.59	0.58	0.78	32.2
Birmingham, AL					
White	0.84	1.33	3.65	4.12	209.8
Black	0.16	0.10	0.88	1.14	1,040.0
Newark, NJ					
White	0.37	0.76	1.21	1.72	126.3
Black	0.18	0.18	0.73	0.69	283.3
Philadelphia, PA					
White	0.69	1.07	1.46	2.05	91.6
Black	0.33	0.48	0.74	1.04	116.7
Washington, D.C.					
White	0.95	1.28	2.18	3.05	138.3
Black	0.31	0.38	0.79	1.43	276.3

Source: 100% Medicare Claims files.

6.0 MODELING THE DIFFUSION OF RELATED TECHNOLOGIES--AN EXPLORATORY INVESTIGATION

6.1 Introduction

For each of the three technology "pairs," the Multistate Data are used to econometrically model the comparative diffusion and interdependence of the two paired technologies. We model, for example, the usage of CABGs as a function of PTCA usage, as well as other factors; and, similarly, we model PTCA usage as a function of CABG volume, and other factors. The same is done for CT and MRI usage, and also for lithotripsy and surgical stone removal.

The following are the kinds of questions we would like to answer from our analyses:

(1) For each technology pair, are the two technologies substitutes or complements?

(2) What factors facilitate or impede the diffusion of each technology?

(3) How important is "price" (i.e., the reimbursement rate) in determining the rate of diffusion?

(4) How quickly will the different technologies adjust to their equilibrium levels?

(5) For each technology, what is its equilibrium level of use?

Each of these questions is discussed below.

Substitutes or complements? Strictly speaking, the technology pairs are not "competing" technologies, inasmuch as the use of one technology in a "pair" does not altogether preclude the use of the other. Nevertheless, there is a strong presumption that the "newer" technologies being studied will eventually replace or substitute for the "older" ones.

The process of technology "succession," however, is not well understood. Eisenberg et al. (1989), found that new diagnostic services often complement rather than substitute for older ones. "It appears that there is a period after adoption of a diagnostic test when the new test is used primarily to complement, rather than substitute for, the older test, that it has the

potential to replace. (p. 1200) Eisenberg et al., thereupon conclude that the introduction of new technologies, without the necessary abandonment of the older ones, contributes to increasing health care costs.

We conduct a similar investigation vis-a-vis each of the three technology pairs included in this study. We are interested in determining, for example, whether and to what extent the adoption of PTCA has led to greater use of CABGs? Furthermore, we would like to know if there is there any evidence that PTCA is now beginning to substitute for CABG?

Eisenberg et al., focused exclusively on diagnostic services. However, only one of our three technology pairs (CT vs. MRI) involves diagnostic technologies. The other two (CABG vs. PTCA; and ESWL vs. stone removal) involve therapeutic or treatment technologies.

Factors affecting diffusion? A variety of studies (e.g., Cromwell and Pope, 1988; Sloan et al., 1986) use multivariate statistical techniques to distinguish the factors associated with diffusion of health care technologies. Most such investigations, however, are conducted in the context of evaluating the effects of hospital rate-setting on hospital usage of technology. Comparatively little attention, by contrast, has been given to modeling health care technology diffusion in the larger community (i.e., on a community-wide basis).

If a "new" technology has been favorably evaluated, policy-makers may wish to accelerate the diffusion of that technology. On the other hand, if a technology has been unfavorably or ambiguously evaluated, policy-makers may wish to slow or reverse the on-going diffusion of that technology. Short of regulatory-type intervention, however, we currently have little information to guide the policy-makers in pursuing either objective.

Although the foregoing studies have provided some insights, we need to develop a much more comprehensive and dependable understanding of the factors that facilitate or impede the diffusion of health care technologies. Until we have such an understanding, we cannot begin to "manage" the technology diffusion process--or, for that matter, to reduce clinical practice variation between different geographic areas.

The importance of price? In Medicare and many other health insurance programs, the "price" paid to the provider for a given service or procedure is set, or indirectly controlled, by

the insurer itself. Thus, to the extent that technology diffusion depends upon the price received by the provider, we have a convenient "policy variable" for potentially influencing the pace of technology diffusion.

Quite surprisingly, however, no one seems to have investigated the importance of price in shaping the diffusion of health care technologies. We do not currently know whether reimbursement price-setting gives us a "weak" or a "strong" policy tool. Our analysis of the Multistate Data will suggest the latter.

Speed of adjustment? For a variety of reasons, different technologies take more or less time to be diffused throughout the country. To the extent that technologies are complex, require expensive investments or have been ambiguously evaluated, those technologies take longer to be accepted and widely used. However, apart from such qualitative considerations, we don't have much understanding of how quickly (or how slowly) specific technologies are adjusting towards their long-run equilibrium values.

We would like to know, for example, whether PTCA usage is approaching equilibrium more or less rapidly than CABG use. In addition, we would like to know how long it will take for MRI usage to stabilize, i.e., how long it will take for the diffusion of this technology to be completed. For the six technologies analyzed herein, this study will attempt to measure their comparative speeds of adjustment to equilibrium.

The equilibrium level of use? This is a much more difficult question to answer. In order to ascertain where one will end up, one must use the available information to extrapolate into the future. There is no assurance, however, that the current patterns of technology diffusion are stable and can be reliably extrapolated. New information on the efficacy of CABG, for example, may become available next year and altogether alter its growth path and its equilibrium level of use. The best we can do is to efficiently utilize the available information to answer a "partial equilibrium" question, namely, if nothing else changes, what would be the level of usage when the technology is fully diffused?

The above questions are "positive" questions, that is, questions about "what is" or "what will be." Assuming that the state-of-the-art permits, they can be answered, in varying degrees, from econometric analysis of historical data. However, another question cannot similarly be answered from multivariate modeling:

(6) For each technology, what is its "optimal" level of use?

This is a "normative" question, that is, a question about "what should be." Although we cannot answer this question from our analyses, it is nevertheless important to acknowledge that this normative question is ultimately the most important question of all. We may have a good understanding of how a given technology is being diffused and what its equilibrium level will be; however, if we don't know whether or not that equilibrium is socially-appropriate, we can't offer the policy-maker much guidance.

Somehow or other, the policy-maker must answer the normative question from other information sources. The history of health care technology is replete with examples of new technologies being adopted and subsequently shown to be ineffective or even damaging (e.g., see McKinlay, 1981). Before doing anything, the policy-maker must first determine that a given technology will provide meaningful benefits.

6.2 Conceptual Discussion

The adoption and diffusion (i.e., expanded use) of a new technology can be portrayed using the economist's usual "supply and demand" framework. Until a new technology has been developed and introduced, the supply of that technology is zero. In the initial stages of technology diffusion, a small number of "innovators" provide a limited supply (Greer, 1988)--and we suggest that the supply curve (S_1 in Figure 6-1) is comparatively inelastic. Indeed, in the early stages of technology development, there is typically no market whatsoever for the technology since insurors decline to pay for "experimental" procedures.

Over time, as the technology is proven and providers become familiar with it, the supply curve shifts outward from S_1 to S_2 and then to S_3, and the supply curve becomes more elastic as the technology becomes increasingly subject to the usual marketplace pressures affecting the allocation of scarce resources. This shifting out of the supply

curve over time, as more information becomes available and that information is more widely disseminated, is what we call the technology "diffusion" process. Eventually, as the technology becomes "mature" and is fully diffused, the supply curve shifts out to its equilibrium level (S* in Figure 6- 1). At this point, the available information on the technology has been fully disseminated to the provider community and providers have fully adapted actual practice behavior to take account of that information.

We shall consider that, once a technology has been judged reimbursable (i.e., determined to be nonexperimental), the demand for that technology (D* in Figure 6-2) is comparatively elastic. For example, in Medicare, the carriers basically pay a fixed dollar amount per procedure, irrespective of volume; and those beneficiaries with supplemental insurance are altogether insensitive to the co-insurance amount. Only at the quantity margin, for those beneficiaries without supplemental insurance, would one hypothesize a greater price elasticity (as depicted from D* in Figure 6-2).

This discussion suggests that, in the early stages of technology diffusion, the quantity provided will vary positively with the reimbursement "price." Demand for the new technology is almost perfectly elastic at the "administered" price level, but the supply of that technology is thought to be considerably more inelastic. Only as the technology matures and supply shifts into the more inelastic range of the demand curve, might we anticipate that the volume of services actually provided would vary inversely with price.

Analytic Implications. Our discussion above implies that the analysis of technology diffusion involves modeling the process of disequilibrium adjustment itself. This seemingly innocuous insight has rather profound analytic implications. It means that, in modeling technology diffusion, it is not sufficient to take into account the usual supply and demand factors (i.e., the same ones that would be important in modeling a mature service). In addition, one must also take into account those factors that shift the supply curve towards its equilibrium level.

Consider, for example, that one is looking at the usage of MRI in different parts of the country. First, however, let us posit that the usage rates in different areas are different, at least in part, because the extent of technology diffusion also varies systematically by area.

The usage of MRI may be nearly mature in Philadelphia but highly immature in some other, more rural locale. If so, we must ask, "What accounts for the fact that the MRI technology has diffused more quickly in Philadelphia?"

We suggest that two conceptually-different factors may be responsible for or explain geographic differences in the extent of technology diffusion:

- geographic differences in the speed of adjustment to equilibrium; and
- geographic differences in the accuracy of adjustment.

We now explain what is meant by each of these factors and discuss the differences between them.

The speed of technology diffusion (i.e., its rate of adjustment to equilibrium) depends, in part, upon the complexity of the technology itself, the capital investment involved in using the technology, and the ambiguity of the technology's evaluation. All of these factors, however, are common or invariant by geographic area. On the other hand, the difficulty of disseminating information, building professional consensus and underwriting the requisite capital investments may vary importantly be area--and such differences imply differences in the rate of technology adoption and use. For example, larger hospitals may find it easier to make the capital investment; or the closer proximity of the medical community in urbanized areas may make it easier to build consensus that a new technology is indeed appropriate and beneficial.

The "speed of adjustment," however, is not the same as the "accuracy of adjustment." One community may be quick to adopt new technologies, even if those technologies are subsequently shown to be ineffective, whereas another community may be more adept at selecting and adopting appropriate technologies. For example, a number of studies (e.g., Winslow et al., 1988) have indicated that the CABG rate is already too high, in a normative sense. If so, we may find that the CABG rate is lower in certain areas that have evaluated and applied the technlogy more appropriately--and that their supply curve has already shifted in the opposite direction.

The accuracy of adjustment, of course, depends upon the "quality" of the evaluative information available on the technology itself. In principle, the same "state-of-the-art"

information is universally available to all communities. Nevertheless, different communities may vary importantly in terms of their ability to "process" the available information; and communities may vary in terms of their ability to modify the already established momentum of the technology diffusion process. For example, a community with a strong medical school presence may be more receptive and more responsive to new research findings; and the providers in such a community may converge more reliably (albeit more cautiously) towards the long-run equilibrium for a new technology.

To conclude this discussion, the analyst must go well beyond the usual "supply and demand" context in modeling the diffusion of new health care technologies. One must also take account of various cultural, sociological and organizational dynamic factors that are less familiar to most economists.

6.3 Operational Specifications

In responding to the analytic questions posed above, we actually estimate three different sets of models:

(1) a structural model of technology diffusion and technology interdependence;

(2) a "first difference" model of technology diffusion; and

(3) a model of the dynamic adjustment process in technology diffusion.

As will be seen, each of these modeling efforts exploits different analytic opportunities and answers different questions about the technology diffusion process. Taken together, the three analyses provide a richer and more comprehensive understanding than would otherwise be possible--given data limitations and econometric constraints. The structures, specifications and rationales for estimating each of these models are presented below.

6.3.1 Structural Model

Among other things, we are interested in modeling the interdependence of the two technologies in each of the technology pairs. We want to determine analytically whether the

"newer" and "older" technologies, as presently used, are substitutes or complements. In order to answer this question we estimate the following structural model:

(1) $Q_1 = f_1(P_1, Q_2; X)$

(2) $Q_2 = f_2(P_2, Q_1; X)$

where

Q_1 = the "quantity" of the first technology;
Q_2 = the "quantity" of the second technology;
P_1 and P_2 = the respective "price" variables; and
X = a vector of demand, supply and supply curve shift factors.

This model has that Q_1 and Q_2 (the two technologies) are reciprocal functions of one another. Thus, we have a joint product-type specification that permits us to explicitly evaluate the nature of interdependence between the two technologies in each technology pair. If, for example, Q_1 is found to vary directly with Q_2, it indicates that the two technologies are complements; and if Q_1 is found to vary inversely with Q_2, it tells us that the two technologies are substitutes.

The hypothesized interdependence of the two technologies nevertheless means that the model system must be estimated using a simultaneous-equations technique (e.g., two-stage-least-squares). Q_1 and Q_2 are both endogenous variables and, in order to achieve identification, the number of excluded exogenous variables in each relationship must be greater than or equal to the number of included endogenous variables. This condition is met by excluding P_2 from the relationship in (1) and excluding P_1 from the relationship in (2).

Ordinarily, in modeling supply and demand relationships, the price variables--P_1 and P_2--would also be endogenous. However, as alluded to above, Medicare reimbursement price levels are not determined in the marketplace. They are set administratively. Nevertheless, to avoid all concerns about potential endogeneity, the price variables in (1) and (2) are lagged one year. That is, we consider that the quantity provided in this year depends

upon last year's price. Such an assumption is hardly unrealistic. It is doubtful that providers know themselves, on a contemporaneous basis, what they'll be paid for the services they're currently providing. However, providers probably know what they've been paid in the past.

For each technology pair, the relationships in (1) and (2) are estimated as linear models using the two-stage-least-squares procedure. In so doing, the reduced-form relationships in (3) and (4) below were also estimated using ordinary-least-squares:

$$(3) \quad Q_1 = g_1(P_1; P_2; X)$$

$$(4) \quad Q_2 = g_2(P_2; P_1; X)$$

Formally, reduced-form relationships are derived from the structural relationships by solving for each of the endogenous variables so as to eliminate the other endogenous variables from the right-hand-side. These models provide both the "own" and "cross" price effects.

The "Q" variables are measured as the rate or number of technology "users" per 1000 beneficiaries. The "P" variables are calculated as the average allowed charge per procedure.* However, these price variables are also adjusted for regional practice cost variation, in order to more reliably depict regional variation in the "real" pecuniary incentives offered to providers.**

For each technology pair, the vector of "X" variables is indicated from Table 6-1. These variables are discussed below. Following the conceptual discussion above, we group them into three categories--(1) demand variables, (2) supply variables and (3) shift factors.

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*In order to standardize price comparisons, the average price variables calculated for CT and MRI included professional reimbursement, respectively, for "head and brain" and "brain and brainstem" scans only.

**All price variables were adjusted using the Geographic Practice Costs Index (GPCI). The GPCI is a national index of practice costs based on physician and nonphysician labor inputs, office rents and malpractice premiums. Since the six technologies studied are typically performed by urban physicians (regardless of patient residence), the state-level average for urban areas was used for rural and non-MSA areas.

Demand Variables. The "left-hand side" user rates are, consistent with other analyses reported herein, already age- and sex-adjusted. Consequently, we need not include Medicare age and sex distribution variables on the "right-hand side." However, inasmuch as black and white differences in utilization were not similarly controlled, we include the percentage of Medicare beneficiaries who are black as a demand-side variable.

Other demand-type variables were not measured for Medicare beneficiaries and must be proxied from information available on the larger population. Proxy variables include average per capita income, percent poverty, educational distribution variables (e.g., percent with college degrees) and employment mix variables (e.g., percent white collar). Percent urban is another "traditional" demand variable; however, as we shall suggest below, it may also have another interpretation in the context of this study.

Supply Variables. We include a number of straightforward supply measures-- the patient care physician-to-population ratio, the short term hospital bed-to- population ratio and the average hospital occupancy. In addition, the percent of active physicians in office-based settings is taken to measure the comparative supply of ambulatory health care services. Finally, the specialty-specific physician-to-population ratios, as appropriate to each technology pair, measure the availability of those physicians who actually provide the procedures. We, of course, hypothesize that a greater supply of specialists means a higher use rate.

Information on the within-area availability of the technologies being studied (e.g., percent of hospitals with open heart surgery) was also available. We did not include such "facility" supply variables, however, because of "endogeneity" concerns. In particular, we believe that such facility variables are themselves determined by the same factors that determine the use of that technology. For much the same reason, we chose not to use information on Medicare assignment rates.

Shift Factors. The "shift" variables are intended to "capture" geographic differences in the "speed" and "accuracy" of adjustment to equilibrium. While the two categories, speed and accuracy, are conceptually different, it is not so easy to similarly differentiate the proxy variables.

The ease of building physician consensus, and facilitating technology diffusion, is hypothesized to vary directly with the homogeneity of the provider community. Thus, we predict that technology use rates will be higher in those areas with higher percentages of U.S. and in-state medical graduates. It should also be easier to share information and build consensus in urbanized areas.

We further hypothesize that new technologies will be disseminated more quickly and more appropriately in communities that have a stronger teaching orientation. The relative importance of teaching is measured from three different variables--the percentage of area physicians in teaching, the medical school enrollee-to-population ratio and the teaching hospital percentage.

The average hospital size is taken as a measure of the medical community's ability to underwrite capital investments in new technology. Other things equal, larger hospitals are thought to have easier access to capital.

An HMO variable is included to measure geographic differences in the importance of managed care. On balance, we hypothesize that managed care will be more deliberate in evaluating and supporting the appropriate dissemination of new technology. However, this HMO variable is not specific to Medicare.

Finally, we include information on the age distribution of the specialities that provide the technologies. We reason that the younger physicians within each specialty will be more knowledgeable and more receptive to new research findings. Thus, we hypothesize that they will practice more appropriately, i.e., more nearly consistent with emerging clinical consensus.

All of the demand, supply and shift factor variables referenced above come from the Area Resource File (ARF). Whereas we have information on the left-hand side variable for 1985-1988, the right-hand size ARF variables were typically measured only once over this same interval. Consquently, a pooled cross section/time series analysis would not be appropriate, since the right-hand side variables don't vary over time. The models are thereupon estimated for a single cross section, using the 1987 utilization rates and 1986 reimbursement prices. This also enables us to include Wisconsin market areas and thereby increase our sample size to 109.

6.3.2 First Difference Model

The diffusion of new technology is frequently depicted as an S-shaped function of "time," as shown in Figure 6-3. However, we consider that, at any time (i.e., any year), different areas of the United States are "positioned" at different points along this curve. For example, in 1987, Philadelphia may be at point A, whereas rural Pennsylvania may be at point B.

If one accepts the proposition, that Q (i.e., the actual extent of technology diffusion) is a proxy for "time" (i.e., time elapsed since diffusion began in a given area), we can then take Q itself as a proxy for "time." This implies that the "slope" of the S-shaped function, at any given point, is a nonlinear function of Q. Indeed, we posit that this function can be approximated by a cubic function of Q as shown below:

$$\Delta Q/Q = \beta_0 + \beta_1{}^*Q + \beta_2{}^*Q^2 + \beta_3{}^*Q^3 + \gamma^*X \tag{5}$$

where

$\beta Q/Q$ = the difference between the 1987 and 1986 utilization rates, divided by the 1986 rate; and

X = the vector of demand, supply and supply curve shift variables, as discussed above.

In principle, the estimation this empirical relationship should enable us to "describe" what happens to the rate of diffusion as the actual level of diffusion itself increases. Furthermore, if the relationships obtained are sufficiently stable, we should be able to extrapolate and predict the "equilibrium" level of use (i.e., the level at which diffusion is complete)--or possibly even forecast declining usage for those older technologies which are being superseded by newer ones.

Our first difference analysis is admittedly unconventional and experimental. Nevertheless, the results demonstrate that this approach has considerable merit.

6.3.3 Dynamic Adjustment Model

We are also interested in gauging the relative rate at which the six technologies examined herein are adjusting to their long-run equilibrium levels. This is done explicitly by modeling the dynamic or disequilibrium adjustment process.

Consider that technology diffusion involves a partial adjustment process as follows. For each technology, its equilibrium or "desired" value, Q_*, is not directly observable, but, over time, its actual level, Q^t, converges systematically towards the desired level. The adjustment is not complete in any given time period, however, because of informational constraints, investment requirements, and habit persistence. Positing a geometric lag distribution for the partial adjustment process (see Kmenta, 1971), we have the following as a dynamic analog of the reduced-form relationship in (3) above:

$$(6) \quad Q_1{}^t = \beta + \lambda^* Q_1{}^{t-1} + \alpha^* P_1 + \delta^* P_2 + \gamma^* X$$

where

$\lambda =$ the "dynamic adjustment coefficient."

The dynamic adjustment coefficient (λ) provides a direct, quantitative measure of the relative rate of dynamic adjustment for each technology. The "partial adjustment" model assumptions imply that λ varies between 0 and 1. If $\lambda = 0$, no lagged adjustment is indicated, implying that equilibrium is achieved on a contemporaneous, year-to-year basis. However, as λ approaches one, the duration of the adjustment process increases without limit. The specification for Q_2 is the same.

6.4 Results

The results are reported separately for each of the three model types--(1) structural, (2) first difference and (3) dynamic adjustment. Afterwards, in section 6.5, we summarize the findings and indicate general conclusions.

A maximum of only 109 observations were available for estimating the various relationships, 78 MSAs and 31 rural areas.* However, because of various "missing data" problems, a somehat smaller number of observation were actually available for estimating each model.

Given the comparatively small sample, it should not be surprising that some of the results reported below are sensitive to model specification. The reader is forewarned that, despite our best efforts, parameter instability has remained a problem. For this reason, the study is explicitly identified as being "exploratory" in nature.

In the "structural" and "dynamic" models, the left-hand-side variable was measured as the 1987 rate of procedure "users" per 1000 Medicare beneficiaries. In the "first difference" model, the dependent variable was measured as the percentage change in user rates from 1986 to 1987. All regression models were weighted by the number of beneficiaries residing in each observational unit.

6.4.1 Structural Model

The structural models were estimated by two-stage-least-squares. The "first stage" (i.e., the reduced-form models) were estimated using the full specification indicated in Table 6-1. However, in order to resolve multicollinearity problems, the "second stage" was estimated using a stepwise regression approach as follows.

The "price" variable and the endogenous related technology variables (e.g., Q_2 in the Q_1 model) were forced to enter the structural models. However, the other variables (i.e., the "X" variables) were entered and retained only if they were significant at the .30 level or better (a reasonably conservative criterion).

The structural results for each technology pair (CABG vs. PTCA, CT vs. MRI and stone surgery vs. ESWL) are reported in Table 6-2. In order to more effectively elucidate the overall

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*Unlike the other analyses in this report, information from Wisconsin was included in order to maximize the number of observations available.

pattern of results, the parameter estimates obtained from all the structural models are discussed together by variable category.

The Alternate or Related Technology Variables. The related or alternate technology variables are significant (.10 level or better) in all except the MRI and stone surgery models. For those two technologies, it appears that the related technology is neither a complement nor a substitute.

The results suggest that CABG and PTCA, as these technologies are used, are reciprocal complements. An area with a higher PTCA user rate also has a higher CABG rates, and vice versa. Stone surgery is similarly found to be "complementary" to lithotripsy; that is, at the margin, a higher stone surgery rate implies a higher lithotripsy rate. However, as noted above, the opposite is apparently not true. Our results imply that lithotripsy is somehow used differently and, at the margin, it does not presently impact on the use of stone surgery.

Our results suggest that MRI, at the margin, is a near perfect substitute for CT. The coefficient on the MRI variable in the CT model is -.95. On the other hand, CT does not seem to similarly substitute for MRI. This suggests that, at the margin, CT is being used differently (e.g., for a different case mix) than MRI, but not vice versa.

The Price Variables. The price variables are significant and positive in the CABG and lithotripsy models; and the price variable is positive and nearly significant in the MRI model. Furthermore, in the reduced-form models (not shown) the "own" price variables are significant and positive in the PTCA and CT models, and the price variable is significant and negative in the stone surgery model.

Our results clearly demonstrate the importance of price in influencing the rate of technology diffusion. Consistent with our theoretic discussion, for five of the six technologies, the quantity provided varies directly with the reimbursement price. Only for the "oldest," most nearly mature of the six technologies, does it appear that "demand-price" pressures constrain the rate of use.

Demand Variables. One or more of the "demand" variables entered each of the six technology models. In fact, three or more demand variables were included in four of the six

models. The signs of the coefficients are not altogether consistent from one model to another, possibly due to multicollinearity. Nevertheless, our results indicate the following patterns.

With the exception of the PTCA model, the technology use rates vary inversely with per capita income and higher education. That is, the more affluent and more highly educated communities appear to have lower use rates. On the other hand, other things equal, the use rates are significantly higher in those areas with more white collar employment. This variable could be proxying the availability of health insurance in the general population; and practice patterns vis-a-vis the under-age 65 population may "spill over" to the Medicare- age population.

The CT and lithotripsy rates vary directly and significantly with the percentage of Medicare beneficiaries who are black. This could reflect underlying differences in the incidence and manifestations of health care problems in the black Medicare population.

Supply Variables. Somewhat surprisingly, our results suggest the provider supply differences are not major factors affecting the comparative rates of technology diffusion in different geographic areas. In general, provider setting appears to be more important than the aggregate provider supply. For three of the six technologies--CABG, CT and MRI--the use rates are signficantly lower in areas with a higher percentage of office-based physicians. This implies, not surprisingly, that a relatively greater supply of hospital-based physicians increases the supply of these services.

Traditional supply variables are important, and consistent with expectations, in the PTCA model. We find that the rate of PTCA use varies directly with the hospital bed-to-population ratio, and that it varies inversely with the average hospital occupancy rate. However, we also find (1) that a higher bed-to-population ratio is associated with a lower lithotripsy rate and (2) that a higher physician-population-ratio is associated with a lower CT rate. These results are more difficult to explain. Perhaps, areas with a greater provider supply are using other, more provider-intensive substitutes (ones not investigated herein) for these two technologies.

Shift Factors. The supply curve "shift" parameters were found to be remarkably important in explaining geographic variation in the diffusion of the six technologies studied

herein. In fact, the specialist age distribution variables are significant in all except the stone surgery model. Although the results are somewhat equivocal, they generally indicate that the technology use rates are higher, as predicted, in areas with relatively younger specialists. However, although not quite significant, there is also an indication that the lithotripsy rate is lower for the youngest urologists.

As hypothesized, the extent of homogeneity in the physician population is also important in determining technology diffusion rates. In particular, the CT, MRI and lithotripsy rates are significantly higher in areas with a higher percentage of within-state medical graduates. In addition, the CABG and lithotripsy rates vary directly with the percentage U.S. graduates.

Although the CT rate is found to vary inversely with percent U.S. graduates, that finding is not necessarily inconsistent with expectations. Our prediction was that provider homogeneity will catalyze the pace of technology diffusion. However, if there were a growing consensus that CT is being over- utilized, we should also predict that greater homogeneity would speed the diffusion of that information and facilitate a reversal of the established momentum.

Teaching variables were important in all except the stone surgery model. In general, we found that the extent of technology diffusion varied inversely with two variables proxying the relative importance of teaching to the community- --(1) percent teaching hospitals and (2) the medical school enrollee-to- population ratio. Assuming teaching-oriented communities use the technologies more appropriately, our results could suggest that the technologies are being over-utilized elsewhere. There was, however, one exception to this pattern. The results indicate that PTCA use is higher in areas with a relatively larger medical school presence.

Average hospital size is significant in the stone surgery model, and nearly significant in the CT model. In both instances, the coefficients are positive, as predicted. However, neither technology involves the kind of investment where hospital size should be a factor.

In general, percent urban was not found to be an important factor in explaining differential rates of technology diffusion. This variable is significant (with the anticipated

positive sign) only in the PTCA model. Thus, contrary to expectations, there is little indication that information availability problems are a significant factor in less urbanized areas.

Also, in this regard, we should perhaps underscore that we have correlated technology use to provider supply and supply shift parameters within the areas where the beneficiaries actually live. For the technologies being studied, however, the beneficiaries living in rural areas are most likely going to nearby MSAs for services. This suggests that, in future analyses, it might be more appropriate to relate rural/non-MSA use to the supply characteristics of the nearest MSA.

6.4.2 First Difference Model

Our results strongly supported the fundamental premise of this analysis, namely that, the "first difference" or rate of technology diffusion varies systematically with the actual level of diffusion. Plausible empirical relationships were obtained for all except lithotripsy, which exhibited the volatility typical of a new technology in its earliest stage of diffusion.

The model obtained for MRI is depicted in Figure 6-4. The average level of MRI use in our sample was 4.3 "users" per 1000 beneficiaries. At this level, the graphic relationship indicates that the rate of growth in MRI may be expected to increase beyond a plateau of comparatively slow growth. Indeed, assuming that the current pattern of MRI diffusion continues, we calculate that MRI growth will not stop until the average use rate increases to 25.3 per 1000 beneficiaries, about six times its current level in our data. Only one of the sample observations is already at that level.

The models obtained for the four other technologies (excluding lithotripsy), though not portrayed graphically, gave similarly "interesting" results. However, unlike MRI, these other models indicate monotonically- decreasing growth (i.e., there is no "bump" or region of increasing growth such as we see in Figure 6-4). Our results indicate that growth will stop and begin declining when usage reaches the levels indicated below:

	Model	Level	Mean	Ratio
1)	CABG	5.50	3.32	1.6
2)	PTCA	4.75	1.72	2.6
3)	CT	89.0	56.4	1.6
4)	Stone Surgery	2.62	1.18	2.2

We also indicate above the means levels of usage from our sample; and we divide the mean values into the projected peak levels of usage to obtain the ratios between them. For example, the sample average for CABG is 3.32 users per 1000 beneficiaries. Our results suggest that CABG growth will continue until it reaches 5.5 users per 1000 beneficiaries, equal to 1.6 times the sample average. The results clearly imply that the four technologies above are much nearer to their projected "peak" levels than is MRI. Our results also show that, for the two complete technology pairs, the older technologies are nearer their peaks than the newer ones.

The reader must consider that these calculation are more nearly a methodological exercise or "test" than a serious attempt at prediction. We have no way of knowing if the relationships indicated from the current diffusion experience will in fact be stable over time.

6.4.3 Dynamic Adjustment Model

The dynamic model and the "dynamic adjustment coefficients" were estimated by simply adding a lagged dependent variable to the reduced-form models. The parameter estimates for the dynamic adjustment coefficients (the λ s) are shown below:

	Model	λ Estimate
1)	CABG	.94
2)	PTCA	.69
3)	CT	.95
4)	MRI	1.22
5)	Stone Surgery	.62
6)	ESWL	.59

All of these coefficients are very highly significant. However, two of the λ estimates are near to one, and one of the estimates is actually larger than one. Given that the feasible range for

λ is between zero and one, these findings are rather difficult to interpret--and indeed this quandary largely accounts for our decision not to include a dynamic specification in the structural modeling reported above.

The results clearly indicate that the dynamic adjustment model is not specified appropriately. On the other hand, we found it difficult to develop more satisfactory alternatives using our limited data base (N = 109), and especially one with a very short time series.

Absent other alternatives, we suggest that the above results still have meaning and are broadly indicative of the relative rates of adjustment to equilibrium. As a practical matter, let us consider that a larger parameter estimate (whether or not it falls within the feasible range) implies that a given technology takes longer to adjust to its long-run equilibrium. If so, our estimates can be used to rank-order the six technologies in terms of their relative speeds of disequilibrium adjustment.

The results suggest, for example, that lithotripsy and stone surgery adjust most quickly to their equilibrium levels, and also that MRI is the slowest to adjust. Furthermore, CT and CABG use are estimated to be adjusting at approximately the same rates.

These results are generally consistent with intuition and casual expectations. For example, it is not surprising that MRI, which involves the largest capital investment of all six technologies, should be the slowest to adjust to equilibrium.

6.5 Summary and Conclusions

To summarize, let us come back to the study questions that were posed at the beginning of the chapter and report the extent to which our investigation has answered each of the questions:

(1) For each technology pair, are the two technologies substitutes or complements?

Our results suggest that CABG and PTCA are reciprocal complements. Also, stone surgery is complementary to lithotripsy; and MRI is a near perfect substitute for CT. However,

lithotripsy is neither a substitute nor a complement to stone surgergy; and CT is neither a substitute nor a complement to MRI.

(2) What factors facilitate or impede the diffusion of each technology?

Traditional demand and supply variables were somewhat less important than anticipated; and the patterns were sometimes difficult to interpret, because of multicollinearity. Most importantly, however, our analysis has established the importance of "shift factor" variables in proxying geographic differences in the "speed" and "accuracy" of adjustment to equilibrium. For example, we found that technology diffusion is faster in those areas with more homogeneous provider communities (as proxied by percent within-state medical graduates). A traditional "demand" and "supply" specification is clearly shown to be inadequate for describing the technology diffusion process. Nevertheless, our analysis does not provide any compelling answers to this question.

(3) How important is "price" (i.e., the reimbursement rate) in determining the rate of diffusion?

The "price" variable is shown to be extremely important in determining the rate of technology diffusion. For five of the six technologies, the extent of diffusion was found to vary directly with the "reimbursement price" level. This suggests that reimbursement "price setting" offers a convenient "policy tool" for influencing the pace of technology diffusion.

(4) How quickly will the different technologies adjust to their equilibrium levels?

Our results, though not entirely satisfactory, suggest that there are important differences between the six technologies in their rates of adjustment to equilibrium. We estimate that lithotripsy and stone surgery are adjusting most quickly, and that MRI is adjusting most slowly to equilibrium.

(5) For each technology, what is its equilibrium level of use?

Using empirical relationships that describe the current pattern of technology use, we "go out on a limb" and extrapolate future technology usage. This could not be done for lithotripsy. However, for the other five technologies, we actually calculated the levels at which usage would peak before beginning to decline. Our results suggest that MRI usage will increase about six times yet before declining, whereas the other technologies (excluding lithotripsy) are projected to increase "only" between one-and-a-half and two-and-a- half times before reaching their peaks.

Although this study has indicated a variety of intriguing results, the reader is nevertheless reminded that, for the following reasons, our analyses can only be regarded as being exploratory in nature. Our sample size was limited, with only 109 observational units drawn from just 11 states. In addition, our analyses focus on the experience in one year only. Thus, before accepting our findings--and certainly before formulating any policy decisions based upon them-- we strongly recommend that the analyses be replicated from other, larger data universes and for additional or longer time periods.

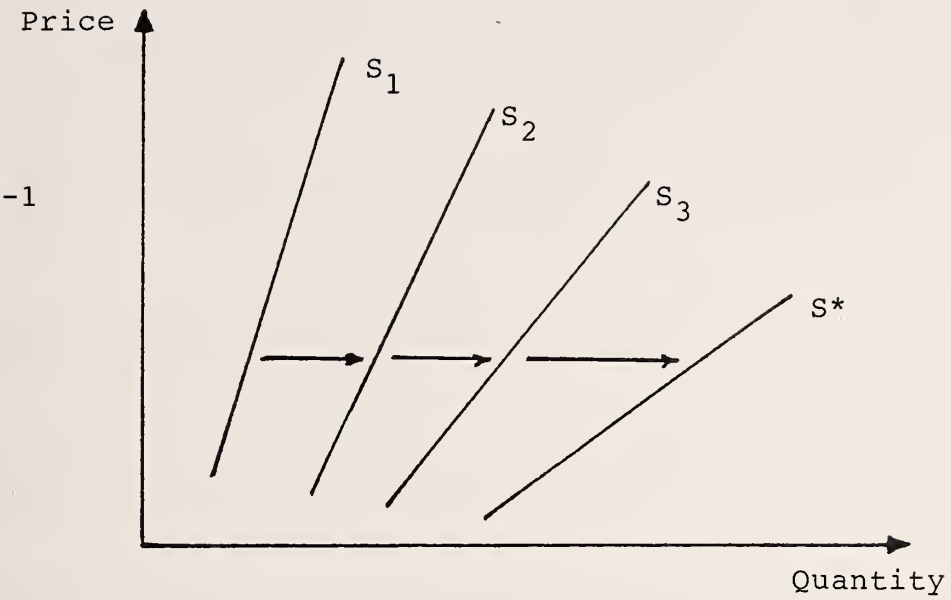
Price
S1
S2
S3
S*
Quantity

FIGURE 6-1

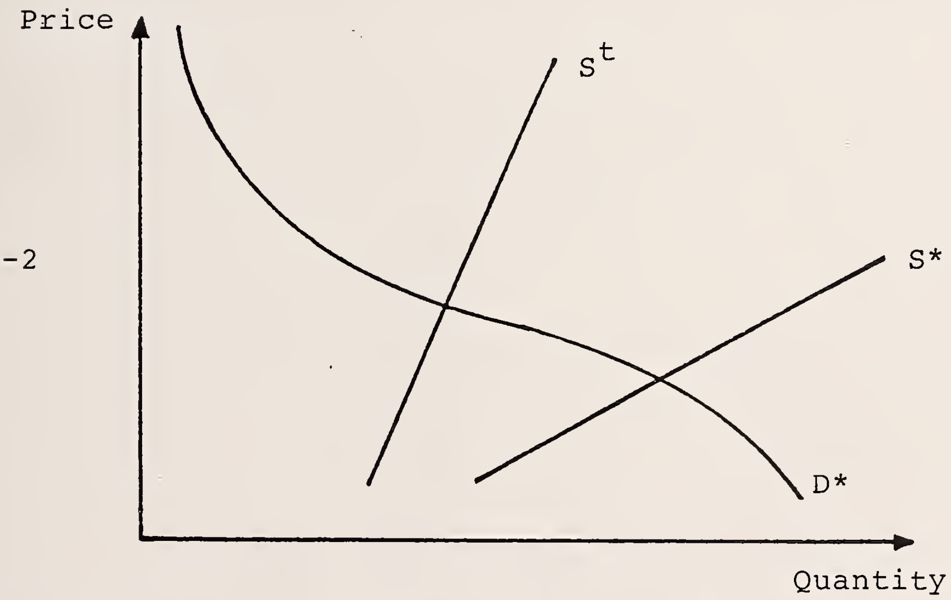
Price
S^t
S*
D*
Quantity

FIGURE 6-2

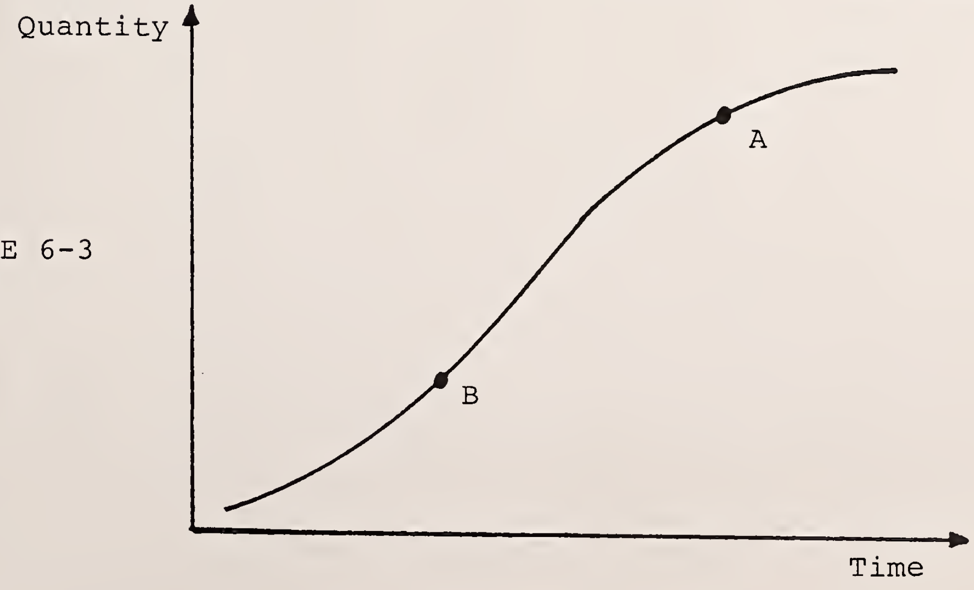
Quantity
A
B
Time

FIGURE 6-3

TABLE 6-1

INDEPENDENT VARIABLES FOR STRUCTURAL ESTIMATION

Variables	CABG	PTCA	CT	MRI	STONES	ESWL
MDs per population	X	X	X	X	X	X
Office-based MDs per all MDs	X	X	X	X	X	X
Teaching MDs per capita	X	X	X	X	X	X
U.S. Medical grads. per all MDs	X	X	X	X	X	X
Instate Medical grads. per all MDs	X	X	X	X	X	X
Short-term hospital beds per capita	X	X	X	X	X	X
Average hospital size	X	X	X	X	X	X
Medical schools per hospital	X	X	X	X	X	X
Members of Council of Teaching Hospitals per hospital	X	X	X	X	X	X
Percent of all short-term general hospitals, beds > 300	X	X	X	X	X	X
Hospital occupancy rate	X	X	X	X	X	X
Medical school enrollees per capita	X	X	X	X	X	X
Proportion of black Medicare eligibles	X	X	X	X	X	X
Average number of HMOs per area	X	X	X	X	X	X
Percent of population that is urban	X	X	X	X	X	X
Per capita income	X	X	X	X	X	X
Percent of population below poverty	X	X	X	X	X	X
Percent of population in white-collar occupations	X	X	X	X	X	X
Percent of population in blue-collar occupations	X	X	X	X	X	X
Persons with high school education or more per capita	X	X	X	X	X	X
Persons with 4+ years of college per capita	X	X	X	X	X	X

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TABLE 6-1 (continued)

INDEPENDENT VARIABLES FOR STRUCTURAL ESTIMATION

Variables	**CABG**	**PTCA**	**CT**	**MRI**	**STONES**	**ESWL**
Cardiologists and thoracic surgeons per capita	X	X				
Proportion of cardiologists per cardio./thoracic MDs	X	X				
Average charge per any CABG procedure	X	X				
Avearge charge per any PTCA procedure	X	X				
Proportion of cardiologists age < 44	X	X				
Proportion of cardiologists age 55+	X	X				
Proportion of thoracic surgeons age < 44	X	X				
Proportion of thoracic surgeons age 55+	X	X				
Radiologists per capita			X	X		
Average charge per any head CT procedure			X	X		
Average charge per any head MRI procedure			X	X		
Proportion of diagnostic radiologists age < 44			X	X		
Proportion of diagnostic radiologists age 55+			X	X		
Proportion of radiologists age < 44			X	X		
Proportion of radiologists age 55+			X	X		
Urologists per capita					X	X
Average charge per any surgical stone removal procedure					X	X
Average charge per any ESWL procedure					X	X
Water Hardness Index (higher = softer)					X	X
Proportion of Urologists age < 44					X	X
Proportion of Urologists age 55+					X	X

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TABLE 6-2

COEFFICIENT ESTIMATES FOR STRUCTURAL MODELS

Variables	**CABG**	**PTCA**	**CT**	**MRI**	**STONES**	**ESWL**
Intercept	-0.349	1.379*	72.007*	1.168	1.313*	-0.584
MDs per population	†	†	-0.002	†	†	†
Office-based MDs per all MDs	-3.065*	†	-26.156*	-10.898*	†	†
Teaching MDs per capita	†	†	†	†	†	†
U.S. Medical grads. per all MDs	0.033*	†	-0.213*	†	†	0.006*
Instate Medical grads. per all MDs	†	†	0.154*	†	0.008*	0.003*
Short-term hospital beds per capita	†	0.001	†	†	†	-0.0006*
Average hospital size	†	†	0.021	†	0.001*	†
Medical schools per hospital	†	†	†	†	†	†
Members of Council of Teaching Hospitals per hospital	†	-0.010	0.265*	-0.053	†	†
Percent of all short-term general hospitals, beds > 300	†	†	†	†	†	†
Hospital occupancy rate	†	-1.813*	15.774	†	†	†
Medical school enrollees per capita	-0.009*	0.005*	†	†	†	-0.001*
Proportion of black Medicare eligibles	†	†	44.296*	8.301	†	0.990*
Average number of HMOs per area	†	†	†	†	†	†
Percent of population that is urban	†	0.001*	†	†	†	†
Per capita income	-0.001	†	†	-0.001*	†	†
Percent of population below poverty	†	†	†	†	†	†
Percent of population in white-collar occupations	†	-0.007*	†	0.016	†	0.002*
Percent of population in blue-collar occupations	†	†	†	†	†	-0.001*
Persons with high school education or more per capita	†	†	†	22.026*	-1.120*	-0.917
Persons with 4+ years of college per capita	-10.816*	10.144*	†	-30.051*	†	-2.779*
Cardiologists and thoracic surgeons per capita	†	†				
Proportion of cardiologists per cardio./thoracic MDs	†	†				
Lagged average charge per any CABG procedure	0.001*					
Lagged average charge per any PTCA procedure	†	0.001				

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TABLE 6-2 (continued)

COEFFICIENT ESTIMATES FOR STRUCTURAL MODELS

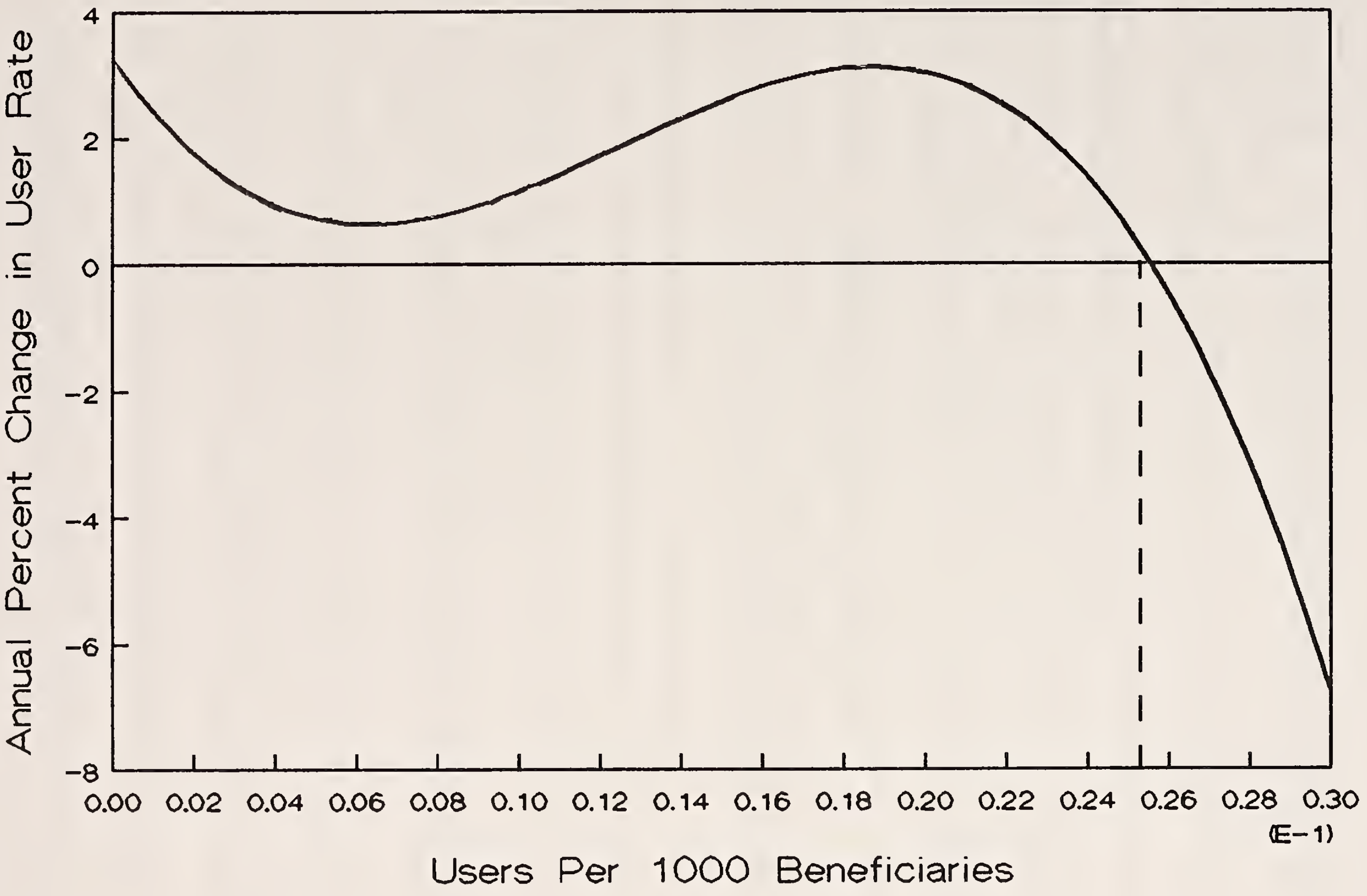
Variables	**CABG**	**PTCA**	**CT**	**MRI**	**STONES**	**ESWL**
Predicted CABG utilization rate		526.707*				
Predicted PTCA utilization rate	808.487*					
Proportion of cardiologists age < 44	1.042*	0.356				
Proportion of cardiologists age 55+	†	0.707*				
Proportion of thoracic surgeons age < 44	†	0.384				
Proportion of thoracic surgeons age 55+	0.357	†				
Radiologists per capita			†	†		
Lagged average charge per any CT procedure			0.002			
Lagged average charge per any MRI procedure				0.003		
Predicted CT utilization rate				-51.818		
Predicted MRI utilization rate			-952.377*			
Proportion of diagnostic radiologists age < 44			7.981*	†		
Proportion of diagnostic radiologists age 55+			-13.309*	†		
Proportion of radiologists age < 44			†	2.949*		
Proportion of radiologists age 55+			3.946	†		
Urologists per capita					†	†
Lagged average charge per any surgical stone procedure					-0.0001	
Lagged average charge per any ESWL						0.0003*
Predicted surgical stone removal utilization rate						530.526*
Predicted ESWL utilization rate					208.645	
Water Hardness Index (higher = softer)					†	†
Proportion of Urologists age < 44					†	-0.185
Proportion of Urologists age 55+					†	0.006*
R-Square	0.422	0.479	0.569	0.213	0.225	0.634

*Significant at .10 level or better.
†Included in the model but not significant at the .30 level or better.

Source: 100% Medicare Part B claims from 12 states, 1987.

FIGURE 6-4

MRI "First Difference" Growth Model



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APPENDIX A

UTILIZATION BY STATE FOR WHITE AND BLACK ELIGIBLES

TABLE A-1

UTILIZATION OF CABG BY WHITES, BY STATE, OVER TIME (USERS PER 1,000 WHITE ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	4.98	5.17	5.57	5.69	10.0%
Urban	5.16	5.46	5.89	5.98	9.5%
Rural	4.69	4.72	5.07	5.23	10.8%
ARIZONA	3.29	2.82	3.22	3.42	21.2%
Urban	3.54	2.95	3.52	3.64	23.5%
Rural	2.33	2.37	2.19	2.65	11.8%
CONNECTICUT	2.63	3.30	3.57	3.72	12.6%
WASHINGTON D.C.	3.32	2.96	2.97	3.58	21.0%
GEORGIA	3.16	3.41	3.77	4.22	23.5%
Urban	3.75	3.91	4.30	4.88	24.8%
Rural	2.45	2.80	3.11	3.38	20.7%
KANSAS	2.89	3.14	3.37	3.88	23.7%
Urban	3.25	3.50	3.64	4.15	18.6%
Rural	2.46	2.70	3.06	3.55	31.6%
NEW JERSEY	1.46	2.44	2.57	2.96	21.6%
OKLAHOMA	2.75	3.05	3.47	4.33	41.9%
Urban	2.94	3.33	3.77	4.81	44.7%
Rural	2.55	2.77	3.15	3.81	37.4%
OREGON	2.07	2.31	2.46	3.28	42.0%
Urban	1.92	2.37	2.40	3.30	39.0%
Rural	2.33	2.20	2.55	3.24	47.4%
PENNSYLVANIA	2.61	3.08	3.77	4.41	43.2%
Urban	2.71	3.16	3.87	4.51	42.9%
Rural	1.95	2.57	3.17	3.73	45.5%
WASHINGTON	3.24	3.76	4.50	5.03	33.6%
Urban	3.34	3.97	4.60	5.00	25.9%
Rural	2.83	3.14	4.20	5.12	63.2%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-2

UTILIZATION OF CABG SURGERY BY BLACKS, BY STATE, OVER TIME (USERS PER 1,000 BLACK ELIGIBLES

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA	1.02	1.12	1.33	1.60	42.2%
Urban	1.15	1.27	1.60	1.83	44.5%
Rural	0.81	0.90	0.91	1.23	36.7%
ARIZONA	5.84	1.21	0.61	1.13	-7.3%
Urban	7.11	1.24	0.79	1.22	-1.6%
Rural	0.99	1.11	0.00	0.80	-27.6%
CONNECTICUT	1.22	1.59	1.45	2.14	34.9%
WASHINGTON D.C.	1.40	0.87	1.72	1.78	103.8%
GEORGIA	0.55	0.76	0.91	0.98	28.9%
Urban	0.77	0.89	1.21	1.16	29.9%
Rural	0.28	0.59	0.54	0.76	28.5%
KANSAS	1.40	1.33	1.00	1.61	20.4%
Urban	1.30	1.70	0.98	1.40	-17.6%
Rural	1.53	0.88	1.03	1.85	110.0%
NEW JERSEY	0.75	0.93	0.98	1.27	36.9%
OKLAHOMA	4.41	1.43	1.01	1.40	-2.1%
Urban	4.13	1.14	1.56	1.27	11.2%
Rural	4.69	1.73	0.44	1.55	-10.6%
OREGON	0.00	0.28	2.51	5.98	2012.4%
Urban	0.00	0.44	0.21	1.09	145.6%
Rural	0.00	0.00	6.31	13.00	--
PENNSYLVANIA	1.12	1.11	1.99	1.55	40.0%
Urban	1.13	1.12	1.79	1.48	32.2%
Rural	1.07	1.04	3.26	2.01	93.5%
WASHINGTON	0.62	1.34	0.98	2.78	107.7%
Urban	0.81	1.78	1.26	2.11	18.2%
Rural	0.00	0.00	0.00	4.83	--
TOTAL	1.31	1.09	1.40	1.78	63.3%
Urban	1.26	1.17	1.36	1.51	29.1%
Rural	1.03	0.84	1.51	2.70	221.4%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-3

UTILIZATION OF PTCA BY WHITES, BY STATE, OVER TIME (USERS PER 1,000 WHITE ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	0.72	1.56	3.14	3.81	144.4%
Urban	0.84	1.59	3.31	4.05	155.2%
Rural	0.55	1.51	2.87	3.42	126.4%
ARIZONA	1.02	1.53	1.96	2.80	82.6%
Urban	1.09	1.64	2.15	2.99	83.0%
Rural	0.75	1.19	1.29	2.16	82.0%
CONNECTICUT	0.51	0.78	1.29	1.92	146.1%
WASHINGTON D.C.	0.95	1.28	2.18	3.05	138.1%
GEORGIA	0.98	1.53	1.97	2.71	76.9%
Urban	1.19	1.88	2.31	3.30	75.3%
Rural	0.72	1.10	1.56	1.96	78.9%
KANSAS	2.08	2.58	2.90	3.64	41.4%
Urban	2.69	3.10	3.33	4.33	39.6%
Rural	1.36	1.94	2.38	2.81	44.4%
NEW JERSEY	0.41	0.75	1.14	1.76	135.4%
OKLAHOMA	0.10	0.67	2.21	3.19	372.8%
Urban	0.08	0.66	2.55	3.91	494.6%
Rural	0.12	0.69	1.85	2.39	246.3%
OREGON	0.80	1.06	1.79	2.33	119.2%
Urban	0.78	1.06	1.72	2.35	123.0%
Rural	0.85	1.07	1.88	2.29	113.6%
PENNSYLVANIA	0.69	1.08	1.56	2.06	90.4%
Urban	0.72	1.12	1.60	2.11	88.1%
Rural	0.48	0.83	1.33	1.75	111.3%
WASHINGTON	0.78	1.62	2.07	2.96	83.0%
Urban	0.83	1.65	2.10	2.92	76.5%
Rural	0.62	1.50	1.97	3.07	105.3%
TOTAL	0.78	1.25	1.88	2.55	104.0
Urban	0.81	1.26	1.87	2.59	105.6
Rural	0.70	1.21	1.89	2.43	100.8

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-4

UTILIZATION OF PTCA BY BLACKS, BY STATE, OVER TIME (USERS PER 1,000 BLACK ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	1.31	0.33	0.71	0.80	141.4%
Urban	0.15	0.34	0.88	0.82	144.2%
Rural	0.09	0.33	0.44	0.77	137.4%
ARIZONA	0.33	0.36	0.73	1.33	268.2%
Urban	0.42	0.46	0.94	1.72	270.1%
Rural	0.00	0.00	0.00	0.00	--
CONNECTICUT	0.34	0.41	0.67	0.98	140.9%
WASHINGTON D.C.	0.31	0.38	0.79	1.43	274.1%
GEORGIA	0.27	0.31	0.43	0.65	109.2%
Urban	0.38	0.48	0.60	0.82	69.8%
Rural	0.13	0.10	0.21	0.44	335.3%
KANSAS	0.76	0.64	1.31	0.70	8.5%
Urban	0.70	1.17	1.46	0.81	-30.9%
Rural	0.84	0.00	1.14	0.57	--
NEW JERSEY	0.17	0.31	0.54	0.85	177.2%
OKLAHOMA	0.00	0.20	0.58	0.50	147.3%
Urban	0.00	0.36	0.58	0.80	124.7%
Rural	0.00	0.04	0.57	0.16	332.1%
OREGON	0.00	1.70	1.64	2.84	67.0%
Urban	0.00	2.65	2.64	4.81	81.3%
Rural	0.00	0.00	0.00	0.00	--
PENNSYLVANIA	0.29	0.39	0.70	0.71	83.3%
Urban	0.34	0.45	0.81	0.76	71.0%
Rural	0.00	0.00	0.00	0.35	--
WASHINGTON	0.30	0.00	0.38	2.72	--
Urban	0.39	0.00	0.48	1.11	--
Rural	0.00	0.00	0.00	7.69	--
TOTAL	0.28	0.40	0.71	1.05	162.5%
Urban	0.31	0.50	0.81	1.07	114.0
Rural	0.18	0.07	0.33	1.01	1,342.9

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-5

UTILIZATION OF CT BY WHITES, BY STATE, OVER TIME (USERS PER 1,000 WHITE ELIGIBLES)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA	50.36	57.70	63.50	71.63	24.1%
Urban	54.79	62.75	67.01	75.27	19.9%
Rural	43.58	49.88	58.02	65.89	32.1%
ARIZONA	44.45	42.47	45.20	48.01	13.0%
Urban	47.43	45.46	47.16	50.24	10.5%
Rural	33.04	32.01	38.48	40.41	26.2%
CONNECTICUT	40.73	45.76	48.93	51.68	12.9%
WASHINGTON D.C.	57.89	56.52	62.73	63.00	11.5%
GEORGIA	51.80	56.65	63.21	69.85	23.3%
Urban	55.89	59.22	65.82	72.09	21.7%
Rural	46.82	53.50	59.95	67.03	25.3%
KANSAS	41.11	46.88	46.86	52.16	11.2%
Urban	49.63	55.04	52.56	56.83	3.3%
Rural	30.84	37.11	39.95	46.51	25.3%
NEW JERSEY	44.74	49.62	53.29	54.91	10.7%
OKLAHOMA	36.18	38.49	42.88	52.33	36.0%
Urban	41.08	42.39	46.82	57.40	35.4%
Rural	31.09	34.42	38.75	46.78	35.9%
OREGON	37.72	39.28	40.88	40.39	2.8%
Urban	38.47	41.32	42.49	42.32	2.4%
Rural	36.46	36.03	38.50	37.61	4.4%
PENNSYLVANIA	58.83	63.21	67.93	70.64	11.8%
Urban	59.99	64.24	68.81	71.44	11.2%
Rural	51.30	56.53	62.31	65.57	16.0%
WASHINGTON	39.15	44.15	47.50	49.73	12.6%
Urban	41.64	45.87	49.49	50.99	11.2%
Rural	31.57	38.88	41.39	45.83	17.9%
TOTAL	49.29	52.67	56.79	60.47	14.8%
Urban	51.50	54.87	58.72	61.93	12.9%
Rural	40.98	44.92	50.05	55.39	23.3%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-6

NUMBER OF CT SCANS ON WHITES, BY STATE, OVER TIME (CLAIMS PER 1,000 WHITE ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	58.70	67.28	74.94	84.79	26.0%
Urban	64.27	74.03	79.84	89.71	21.2%
Rural	50.16	56.84	67.27	77.05	35.6%
ARIZONA	49.65	48.49	51.34	54.87	13.2%
Urban	53.17	51.81	53.25	56.96	9.9%
Rural	36.20	36.88	44.77	47.76	29.5%
CONNECTICUT	47.44	53.69	58.05	61.98	15.4%
WASHINGTON D.C.	69.17	68.17	85.25	75.03	10.1%
GEORGIA	61.84	67.99	76.52	81.17	19.4%
Urban	67.39	71.93	80.08	84.20	17.1%
Rural	55.10	63.14	72.09	77.38	22.5%
KANSAS	47.16	52.83	52.86	58.89	11.5%
Urban	57.53	62.48	59.57	64.74	3.6%
Rural	34.65	41.25	44.70	51.83	25.6%
NEW JERSEY	53.95	61.00	66.30	66.05	8.3%
OKLAHOMA	40.02	43.43	48.69	59.32	36.6%
Urban	45.73	48.41	53.89	65.14	34.6%
Rural	34.10	38.24	43.21	52.95	38.5%
OREGON	42.94	45.03	46.86	46.00	2.1%
Urban	44.30	47.90	49.14	48.52	1.3%
Rural	40.66	40.46	43.48	42.38	4.7%
PENNSYLVANIA	70.16	76.56	83.07	87.64	14.5%
Urban	71.88	78.17	84.56	88.99	13.8%
Rural	59.00	66.17	73.52	78.98	19.4%
WASHINGTON	44.15	49.99	53.92	56.54	13.1%
Urban	47.15	52.32	56.36	58.18	11.2%
Rural	35.01	42.84	46.41	51.50	20.2%
TOTAL	58.08	62.53	68.32	72.05	15.2%
Urban	61.04	65.66	71.24	74.32	13.2%
Rural	46.91	51.51	58.11	64.12	24.5%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-7

UTILIZATION OF CT BY BLACKS, BY STATE, OVER TIME (USERS PER 1,000 BLACK ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	43.18	49.46	56.05	65.39	32.2%
Urban	50.94	56.47	63.82	73.26	29.7%
Rural	31.31	38.60	43.90	53.00	37.3%
ARIZONA	138.35	50.60	52.64	60.73	20.0%
Urban	161.48	54.83	55.92	65.91	20.2%
Rural	49.92	35.81	41.38	43.09	20.3%
CONNECTICUT	50.39	58.10	60.31	61.22	5.4%
WASHINGTON D.C.	85.03	44.79	96.20	95.46	113.1%
GEORGIA	47.03	53.01	58.37	70.25	32.5%
Urban	54.25	58.27	64.37	76.01	30.4%
Rural	38.24	46.54	50.90	63.02	35.4%
KANSAS	46.14	49.93	50.40	59.67	19.5%
Urban	58.81	60.00	56.90	63.34	5.6%
Rural	30.59	37.64	42.50	55.23	46.7%
NEW JERSEY	57.55	61.53	68.45	67.08	9.0%
OKLAHOMA	100.56	40.40	46.74	54.81	35.7%
Urban	127.08	46.86	52.80	60.92	30.0%
Rural	73.02	33.66	40.37	48.11	43.0%
OREGON	153.43	38.86	51.15	64.78	66.7%
Urban	159.32	47.81	54.02	53.24	11.4%
Rural	141.69	22.94	46.42	81.36	254.7%
PENNSYLVANIA	68.81	72.48	83.98	89.48	23.4%
Urban	72.12	74.72	86.07	93.06	24.5%
Rural	47.35	58.08	70.55	66.57	14.6%
WASHINGTON	43.54	42.84	52.40	58.53	36.6%
Urban	53.70	49.08	53.78	59.80	21.8%
Rural	10.95	24.13	47.47	54.62	126.3%
TOTAL	64.68	56.98	66.08	71.97	26.3%
Urban	70.04	61.68	70.67	75.69	22.7%
Rural	44.08	40.30	49.67	59.01	46.4%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-8

NUMBER OF CT SCANS ON BLACKS, BY STATE, OVER TIME (CLAIMS PER 1,000 BLACK ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	51.81	60.49	68.27	80.89	33.7%
Urban	61.97	70.25	78.69	91.67	30.5%
Rural	36.25	45.36	51.96	63.90	40.9%
ARIZONA	173.51	60.04	61.18	73.82	23.0%
Urban	193.36	62.48	64.57	79.26	26.9%
Rural	97.62	51.50	49.53	55.31	7.4%
CONNECTICUT	62.69	70.00	75.88	73.09	4.4%
WASHINGTON D.C.	111.10	60.58	141.77	125.20	106.7%
GEORGIA	57.18	65.94	73.48	82.91	25.7%
Urban	66.83	72.30	81.36	89.78	24.2%
Rural	45.45	58.11	63.67	74.28	27.8%
KANSAS	54.14	57.96	58.89	69.63	20.1%
Urban	71.28	71.82	67.39	75.40	5.0%
Rural	33.10	40.98	48.56	62.66	52.9%
NEW JERSEY	70.93	77.00	88.71	82.61	7.3%
OKLAHOMA	109.76	48.53	55.62	66.32	36.7%
Urban	139.37	56.83	64.70	74.31	30.8%
Rural	79.03	39.88	46.06	57.57	44.3%
OREGON	156.52	41.74	56.59	73.14	75.2%
Urban	163.96	50.72	62.74	59.08	16.5%
Rural	141.69	25.78	46.42	93.36	262.2%
PENNSYLVANIA	84.69	91.76	104.09	113.52	23.7%
Urban	89.87	95.89	108.33	119.32	24.4%
Rural	51.10	65.23	76.86	76.46	17.2%
WASHINGTON	51.11	53.18	59.24	66.71	25.4%
Urban	63.64	57.12	60.95	68.85	20.5%
Rural	10.95	41.35	53.15	60.11	45.4%
TOTAL	77.91	70.50	82.02	88.29	25.2%
Urban	85.26	76.66	89.03	93.86	22.4%
Rural	49.66	48.63	57.00	68.89	41.7%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-9

UTILIZATION OF MRI BY WHITES, BY STATE, OVER TIME (USERS PER 1,000 WHITE ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	0.01	4.66	7.78	9.82	110.5%
Urban	0.00	6.49	10.33	12.78	96.9%
Rural	0.01	1.83	3.79	5.14	180.8%
ARIZONA	0.02	2.46	7.18	9.55	288.0%
Urban	0.02	2.85	8.41	10.48	268.3%
Rural	0.00	1.12	2.95	6.37	471.0%
CONNECTICUT	0.00	0.38	0.71	2.47	541.6%
WASHINGTON D.C.	0.67	4.04	8.33	11.73	190.1%
GEORGIA	0.12	1.09	2.59	4.87	347.6%
Urban	0.15	1.29	2.90	5.49	326.7%
Rural	0.09	0.84	2.22	4.09	384.7%
KANSAS	0.10	2.88	5.70	7.64	165.4%
Urban	0.15	4.00	7.12	8.93	123.1%
Rural	0.03	1.53	3.96	6.08	297.0%
NEW JERSEY	0.15	2.33	4.52	6.42	175.7%
OKLAHOMA	0.09	1.44	3.83	5.89	308.8%
Urban	0.13	1.82	5.10	7.31	301.5%
Rural	0.05	1.04	2.49	4.32	314.8%
OREGON	0.24	2.81	5.26	7.64	171.2%
Urban	0.28	3.31	6.01	8.77	164.8%
Rural	0.17	2.02	4.15	6.00	196.8%
PENNSYLVANIA	0.26	2.49	5.02	8.12	225.9%
Urban	0.28	2.68	5.42	8.57	219.9%
Rural	0.12	1.27	2.44	5.18	308.2%
WASHINGTON	0.11	2.22	4.52	6.28	182.2%
Urban	0.11	2.41	4.71	6.37	164.6%
Rural	0.10	1.66	3.95	5.98	260.8%
TOTAL	0.17	2.39	4.87	7.26	203.8%
Urban	0.20	2.68	5.37	7.85	192.9%
Rural	0.07	1.36	3.09	5.18	280.9%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-10

NUMBER OF MRI SCANS ON WHITES, BY STATE, OVER TIME (CLAIMS PER 1,000 WHITE ELIGIBLES)

	1985	1986	1987	1988	*PERCENT CHANGE 1986 - 1988*
ALABAMA	0.01	4.81	8.08	10.24	112.8%
Urban	0.00	6.72	10.72	13.36	98.9%
Rural	0.01	1.86	3.94	5.33	185.8%
ARIZONA	0.02	2.52	7.37	9.84	290.2%
Urban	0.02	2.90	8.63	10.82	272.8%
Rural	0.00	1.19	3.03	6.50	446.7%
CONNECTICUT	0.00	0.39	0.73	2.53	547.3%
WASHINGTON D.C.	0.68	4.22	10.03	12.32	192.1%
GEORGIA	0.13	1.11	2.66	4.98	348.1%
Urban	0.16	1.32	2.97	5.63	325.6%
Rural	0.09	0.85	2.27	4.16	389.0%
KANSAS	0.10	2.93	5.83	7.85	167.5%
Urban	0.15	4.06	7.28	9.18	125.8%
Rural	0.03	1.58	4.07	6.24	295.7%
NEW JERSEY	0.15	2.37	4.62	6.64	180.0%
OKLAHOMA	0.10	1.48	3.93	6.02	305.5%
Urban	0.15	1.88	5.26	7.47	297.4%
Rural	0.05	1.07	2.53	4.42	312.9%
OREGON	0.24	2.85	5.41	7.82	174.8%
Urban	0.28	3.36	6.16	8.95	166.7%
Rural	0.17	2.03	4.29	6.19	204.9%
PENNSYLVANIA	0.27	2.56	5.22	8.62	236.6%
Urban	0.29	2.76	5.64	9.12	231.0%
Rural	0.12	1.31	2.52	5.43	313.8%
WASHINGTON	0.11	2.23	4.67	6.53	192.8%
Urban	0.11	2.50	4.86	6.63	165.5%
Rural	0.10	1.67	4.08	6.20	270.4%
TOTAL	0.17	2.45	5.07	7.57	209.0%
Urban	0.20	2.75	5.61	8.21	198.5%
Rural	0.08	1.39	3.19	5.34	284.2%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-11

UTILIZATION OF MRI BY BLACKS, BY STATE, OVER TIME (USERS PER 1,000 BLACK ELIGIBLES)

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	0.00	2.49	4.11	5.73	130.4%
Urban	0.00	3.39	5.55	7.57	123.4%
Rural	0.00	1.09	1.87	2.82	159.2%
ARIZONA	0.00	0.25	2.01	5.32	2055.7%
Urban	0.00	0.19	2.60	6.01	3016.8%
Rural	0.00	0.44	0.00	0.76	75.6%
CONNECTICUT	0.00	0.22	0.33	2.40	1011.1%
WASHINGTON D.C.	0.29	1.25	5.25	9.39	648.2%
GEORGIA	0.05	0.73	1.42	3.16	332.8%
Urban	0.05	0.86	1.53	3.48	304.6%
Rural	0.05	0.57	1.27	2.74	383.8%
KANSAS	0.04	2.05	3.89	6.00	193.1%
Urban	0.07	2.66	4.73	7.93	198.0%
Rural	0.00	1.30	2.87	3.67	183.3%
NEW JERSEY	0.08	1.80	3.83	4.58	154.1%
OKLAHOMA	0.44	0.54	1.88	3.72	591.0%
Urban	0.86	0.69	2.16	4.71	585.2%
Rural	0.00	0.38	1.59	2.63	587.7%
OREGON	6.56	1.76	8.54	4.25	141.7%
Urban	9.86	0.88	9.88	2.95	235.6%
Rural	0.00	3.32	6.31	6.11	84.2%
PENNSYLVANIA	0.20	2.01	4.18	7.33	264.7%
Urban	0.23	2.17	4.74	8.01	269.9%
Rural	0.00	1.01	0.61	2.99	194.3%
WASHINGTON	0.15	1.29	3.01	6.60	411.1%
Urban	0.19	1.72	3.85	4.21	144.2%
Rural	0.00	0.00	0.00	13.98	--
TOTAL	0.34	1.50	3.49	5.56	270.7%
Urban	0.43	1.66	3.79	5.99	260.8%
Rural	0.01	0.95	1.72	4.04	325.3%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-12

NUMBER OF MRI SCANS ON BLACKS BY STATE, OVER TIME (CLAIMS PER 1,000 BLACK ELIGIBLES)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA	0.00	2.53	4.17	5.89	132.7%
Urban	0.00	3.42	5.64	7.77	127.4%
Rural	0.00	1.15	1.87	2.92	152.7%
ARIZONA	0.00	0.25	2.17	4.82	1854.1%
Urban	0.00	0.19	2.80	6.65	3351.1%
Rural	0.00	0.44	0.00	0.76	75.6%
CONNECTICUT	0.00	0.22	0.35	2.40	1011.1%
WASHINGTON D.C.	0.29	1.31	6.04	9.82	652.1%
GEORGIA	0.05	0.75	1.45	3.22	331.6%
Urban	0.05	0.89	1.59	3.57	299.6%
Rural	0.05	0.57	1.28	2.79	391.8%
KANSAS	0.04	2.09	3.95	6.39	205.4%
Urban	0.07	2.74	4.85	8.20	199.3%
Rural	0.00	1.30	2.87	4.19	223.7%
NEW JERSEY	0.08	1.83	3.89	4.77	160.9%
OKLAHOMA	0.44	0.54	1.88	3.78	602.1%
Urban	0.86	0.69	2.16	4.82	601.9%
Rural	0.00	0.38	1.59	2.63	587.7%
OREGON	6.56	1.76	8.54	4.25	141.7%
Urban	9.86	0.88	9.88	2.95	235.6%
Rural	0.00	3.32	6.31	6.11	84.2%
PENNSYLVANIA	0.20	2.03	4.40	7.91	288.8%
Urban	0.23	2.19	4.89	8.68	295.8%
Rural	0.00	1.01	1.31	2.99	194.3%
WASHINGTON	0.15	1.38	3.01	6.84	397.1%
Urban	0.19	1.83	3.85	4.52	146.3%
Rural	0.00	0.00	0.00	13.97	--
TOTAL	0.35	1.53	3.62	5.86	283.0%
Urban	0.43	1.69	4.11	6.35	275.7%
Rural	0.01	0.96	1.85	4.13	330.2%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-13

UTILIZATION OF SURGICAL STONE REMOVAL PROCEDURES BY WHITES, BY STATE, OVER TIME (USERS PER 1,000 WHITE ELIGIBLES

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	1.26	1.46	1.77	2.06	40.7%
Urban	1.25	1.36	1.72	1.88	37.7%
Rural	1.27	1.61	1.84	2.34	44.9%
ARIZONA	1.16	0.78	0.82	1.36	75.3%
Urban	1.25	0.76	0.82	1.41	85.0%
Rural	0.82	0.82	0.81	1.19	44.7%
CONNECTICUT	0.89	0.98	1.19	1.16	17.7%
WASHINGTON D.C.	1.02	0.90	1.01	1.18	31.5%
GEORGIA	1.44	1.52	1.64	1.63	7.0%
Urban	1.33	1.53	1.60	1.49	-2.8%
Rural	1.57	1.52	1.69	1.81	19.5%
KANSAS	1.09	1.17	1.13	1.31	12.5%
Urban	1.09	1.20	1.28	1.35	12.6%
Rural	1.08	1.12	0.94	1.26	12.4%
NEW JERSEY	0.90	0.99	1.01	1.18	18.2%
OKLAHOMA	1.02	0.93	1.16	1.45	56.6%
Urban	1.09	1.03	1.23	1.45	40.5%
Rural	0.93	0.81	1.08	1.45	77.8%
OREGON	0.67	0.70	0.78	1.04	48.6%
Urban	0.60	0.71	0.80	0.91	27.5%
Rural	0.78	0.69	0.74	1.24	80.3%
PENNSYLVANIA	1.25	1.25	1.30	1.69	35.5%
Urban	1.23	1.25	1.29	1.69	34.7%
Rural	1.39	1.23	1.40	1.73	40.1%
WASHINGTON	0.79	0.81	0.81	0.76	-7.0%
Urban	0.79	0.74	0.78	0.69	-5.6%
Rural	0.79	1.06	0.91	0.95	-9.9%
TOTAL	1.11	1.12	1.21	1.43	27.7%
Urban	1.08	1.10	1.18	1.39	26.4%
Rural	1.22	1.19	1.29	1.59	33.6%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-14

UTILIZATION OF SURGICAL STONE REMOVAL PROCEDURES BY BLACKS, BY STATE, OVER TIME (USERS PER 1,000 BLACK ELIGIBLES

	1985	*1986*	*1987*	*1988*	*PERCENT CHANGE 1986 - 1988*
ALABAMA	0.69	0.79	0.63	0.96	20.8%
Urban	0.67	0.77	0.64	0.92	19.5%
Rural	0.74	0.84	0.62	1.03	22.6%
ARIZONA	1.16	0.16	0.26	0.92	475.0%
Urban	1.46	0.21	0.24	1.19	466.7%
Rural	0.00	0.00	0.34	0.00	--
CONNECTICUT	0.48	0.44	0.66	0.73	65.9%
WASHINGTON D.C.	0.67	0.43	0.59	0.97	125.6%
GEORGIA	0.67	0.83	0.93	0.90	8.4%
Urban	0.67	0.76	0.94	0.79	3.9%
Rural	0.68	0.92	0.91	1.04	13.0%
KANSAS	0.53	0.15	0.41	1.49	893.3%
Urban	0.56	0.28	0.74	1.00	257.1%
Rural	0.49	0.00	0.00	2.08	--
NEW JERSEY	0.74	0.72	1.05	0.83	15.3%
OKLAHOMA	3.28	0.37	0.34	1.00	170.3%
Urban	2.87	0.34	0.53	0.54	58.8%
Rural	3.71	0.40	0.13	1.50	275.0%
OREGON	0.64	0.00	0.04	0.18	--
Urban	0.97	0.00	0.07	0.30	--
Rural	0.00	0.00	0.00	0.00	--
PENNSYLVANIA	0.75	1.12	0.84	0.83	-25.9%
Urban	0.81	1.29	0.97	0.86	-33.5%
Rural	0.32	0.00	0.00	0.67	--
WASHINGTON	0.40	0.64	0.45	1.15	79.7%
Urban	0.53	0.85	0.58	0.17	-80.0%
Rural	0.00	0.00	0.00	4.15	--
TOTAL	0.76	0.69	0.68	0.90	30.4%
Urban	0.78	0.79	0.79	0.79	0.0%
Rural	0.69	0.36	0.31	1.28	255.6%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-15

UTILIZATION OF ESWL BY WHITES, BY STATE, OVER TIME (USERS PER 1,000 WHITE ELIGIBLES)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA	0.00	0.84	0.97	0.91	8.7%
Urban	0.00	0.92	1.02	0.85	-8.4%
Rural	0.00	0.70	0.89	1.01	43.6%
ARIZONA	0.00	0.00	0.54	0.69	--
Urban	0.00	0.00	0.59	0.73	--
Rural	0.00	0.00	0.38	0.54	--
CONNECTICUT	0.00	0.00	0.01	0.09	--
WASHINGTON D.C.	0.00	0.31	0.60	0.52	68.6%
GEORGIA	0.08	0.78	0.94	1.06	35.1%
Urban	0.09	0.84	0.97	1.11	33.1%
Rural	0.07	0.71	0.90	0.98	37.6%
KANSAS	0.00	0.36	0.60	0.56	57.0%
Urban	0.00	0.41	0.66	0.60	46.5%
Rural	0.00	0.29	0.52	0.51	74.5%
NEW JERSEY	0.00	0.14	0.26	0.52	275.5%
OKLAHOMA	0.00	0.16	0.50	0.46	189.1%
Urban	0.00	0.18	0.51	0.57	217.5%
Rural	0.00	0.14	0.48	0.35	147.1%
OREGON	0.00	0.08	0.35	0.43	461.2%
Urban	0.00	0.08	0.42	0.42	435.7%
Rural	0.01	0.08	0.23	0.45	500.1%
PENNSYLVANIA	0.00	0.20	0.47	0.59	198.1%
Urban	0.00	0.20	0.48	0.61	210.5%
Rural	0.00	0.20	0.44	0.43	118.9%
WASHINGTON	0.00	0.16	0.52	0.61	282.8%
Urban	0.00	0.17	0.55	0.63	275.7%
Rural	0.00	0.13	0.42	0.53	311.1%
TOTAL	0.01	0.28	0.52	0.61	117.9%
Urban	0.01	0.26	0.50	0.60	130.8%
Rural	0.02	0.35	0.59	0.64	82.9%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-16

UTILIZATION OF ESWL BY BLACKS, BY STATE, OVER TIME (USERS PER 1,000 BLACK ELIGIBLES)

	1985	1986	1987	1988	PERCENT CHANGE 1986 - 1988
ALABAMA	0.00	0.28	0.46	0.42	50.0%
Urban	0.00	0.26	0.49	0.31	19.2%
Rural	0.00	0.31	0.40	0.61	96.8%
ARIZONA	0.00	0.00	0.00	0.68	--
Urban	0.00	0.00	0.00	0.88	--
Rural	0.00	0.00	0.00	0.00	--
CONNECTICUT	0.00	0.00	0.00	0.07	--
WASHINGTON D.C.	0.00	0.13	0.40	0.47	273.0%
GEORGIA	0.03	0.29	0.42	0.51	75.9%
Urban	0.04	0.34	0.47	0.54	58.8%
Rural	0.03	0.23	0.36	0.48	108.7%
KANSAS	0.00	0.11	0.38	0.12	9.1%
Urban	0.00	0.21	0.24	0.22	4.8%
Rural	0.00	0.00	0.54	0.00	--
NEW JERSEY	0.00	0.05	0.10	0.23	360.0%
OKLAHOMA	0.00	0.16	0.22	0.29	81.3%
Urban	0.00	0.08	0.23	0.20	150.0%
Rural	0.00	0.24	0.20	0.39	62.5%
OREGON	0.00	0.00	0.37	0.18	--
Urban	0.00	0.00	0.59	0.30	--
Rural	0.00	0.00	0.00	0.00	--
PENNSYLVANIA	0.00	0.06	0.35	0.43	616.7%
Urban	0.00	0.07	0.26	0.33	371.4%
Rural	0.00	0.00	0.97	1.02	--
WASHINGTON	0.00	0.18	0.00	0.00	-100.0%
Urban	0.00	0.23	0.00	0.00	-100.0%
Rural	0.00	0.00	0.00	0.00	--
TOTAL	0.00	0.11	0.26	0.33	200.0%
Urban	0.00	0.11	0.22	0.31	181.8%
Rural	0.00	0.12	0.40	0.40	233.3%

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

TABLE A-17

UTILIZATON OF MRI BY WHITES AND BLACKS (claims per 1,000 eligibles)

	WHITES				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.08	1.39	3.19	5.34	284.2%
Size of MSA					
Less than 250,000	0.23	1.79	3.78	6.32	253.1
250,000 - 1 million	0.10	2.94	5.69	8.10	175.5
Over 1 million	0.27	2.82	5.93	8.67	207.4
All Areas	**0.17**	**2.45**	**5.07**	**7.57**	**209.0**

	BLACKS				
	1985	1986	1987	1988	Percent Change 1986-1988
All Rural	0.01	0.96	1.85	4.13	330.2%
Size of MSA					
Less than 250,000	0.18	0.96	5.61	3.38	252.1
250,000 - 1 million	0.80	1.98	3.83	6.71	238.9
Over 1 million	0.23	1.63	4.01	6.70	311.0
All Areas	**0.35**	**1.53**	**3.62**	**5.86**	**283.0**

Notes: (1) Rates are adjusted by age and sex at the area level.
(2) Aggregated rates are weighted by the number of Medicare eligibles per area.

Source: 100% Medicare Claims from 11 States.

APPENDIX B

MSAs SIZE GROUPS

TABLE B-1

AREA NAMES BY RURAL/URBAN POPULATION[1] AND NUMBER OF MEDICARE ELIGIBLES[2]

Population Less Than 125,000

Anniston, AL
Dothan, AL
Gadsden, AL
Albany, GA
Lawrence, KS
Comanche, OK
Enid, OK
Bellingham, WA
Olympia, WA
State College, PA
Williamsport, PA

N = 11
Eligibles = 142,749

Population 125,000 to 250,000

Florence, AL
Huntsville, AL
Columbus, GA-AL
Tuscaloosa, AL
New London-Norwich, CT-RI
Athens, GA
Savannah, GA
Topeka, KS
Vineland-Millville-Bridgeton, NJ
Medford, OR
Salem, OR
Bremerton, WA
Richland-Kennewick, WA
Vancouver, WA
Yakima, WA
Beaver County, PA
Altoona, PA
Sharon, PA

N = 18
Eligibles = 393,331

Population 250,000 to 500,000

Mobile, AL
Montgomery, AL
Columbia-Richland, GA
Macon-Warner Robins, GA
Wichita, KS
Atlantic City, NJ

Population 250,000 to 500,000 ***(continued)***

Trenton, NJ
Eugene-Springfield, OR
Spokane, WA
Tacoma, WA
York, PA
Reading, PA
Johnstown, PA
Erie, PA
Lancaster, PA

N = 15
Eligibles = 658,445

Population 500,000 to 1 Million

Birmingham, AL
Tucson, AZ
Bridgeport-Stamford-Norwalk-Danbury, CT
New Haven-West Haven-Waterbury, CT
Jersey City, NJ
Middlesex-Somerset-Hunterdon, NJ
Monmouth-Ocean, NJ
Oklahoma City, OK
Tulsa, OK
Allentown-Bethlehem, PA-NJ
Scranton-Wilkes Barre, PA
Harrisburg-Lebanon-Carlise, PA

N = 12
Eligibles = 1,236,789

Population Over 1 Million

Phoenix, AZ
Hartford-Middletown-New Britain, CT
Atlanta, GA
Kansas City, MO-KS
Bergen-Passaic, NJ
Newark, NJ
Philadelphia, PA-NJ
Portland, OR
Seattle, WA
Washington, DC-MD-VA
Pittsburgh, PA

N = 11
Eligibles = 2,629,655

Rural Areas

N = 28
Eligibles = 1,452,646

Notes: (1) Populations are based on 1980 Census data.
(2) Based on Medicare eligible person-months (refer to text).

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